BASIS DETERMINATION ACROSS COMMODITY FUTURES

By

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The basis between the cash and futures market is of critical importance in determining the usefulness of using the futures market as a method of reducing price risk. The basis also provides an index for judging market performance because a normal basis should reflect any time, form or location differences. Basis determination models have been developed for storable commodities but there is a gap in the theory pertaining to nonstorable commodities.

In this analysis, a basis determination model is developed that is generalized enough to accommodate storable and nonstorable commodities. Arbitrage is identified as the competitive mechanism that integrates the cash and futures markets. The basis is defined so that it represents a value enhancing transformation, either by time or form. The deviation of the basis from the cost of transformation (basis residual) is a function of the arbitrage potential. In turn, the arbitrage potential is influenced by commodity and market characteristics.

The empirical measure of basis performance is defined as the normalized standard deviation of the basis residual because the distributional properties of the basis determine basis risk. Nine agricultural commodities over a fifteen year period are included. Basis models in which the time from contract maturity is held constant are specified for two, four and six month intervals.

The empirical results indicate that an increase in exports relative to production and an increase in futures market liquidity each significantly decrease variability in the basis residual. An increase in the hedging ratio beyond 50 percent improves basis performance. The results indicate that integration between the markets is strongest when stocks are abundant, consistent with observed basis patterns. As expected, the mean level of the normalized variability in the basis residual is significantly higher for nonstorable as compared to storable commodities.

Changes in the economic or political environment would potentially be expected to influence exports, market liquidity or the hedging ratio and in turn affect basis performance. Changes in storability and the seasonal pattern of stock levels, which require technological advances, are less likely to occur. However, ascertaining that these variables affect basis performance is useful to understanding basis relationships.

CHAPTER I
INTRODUCTION

An important area of analysis in agricultural marketing has been directed to understanding forward pricing mechanisms and how such pricing arrangements affect producer risk, production decisions and the temporal allocation of agricultural output. In the case of the most institutionalized forward pricing mechanisms, the futures market, the bulk of theoretical and empirical investigation has been devoted to storable commodities, where forward or futures prices have a direct influence on the movement of commodities into and out of storage. In particular, research has been directed towards examining the economic advantages arising from futures markets, identifying to whom these advantages accrue and looking at the roles that traders perform within the pricing system.

There is a noticeable gap in the theory pertaining to agricultural commodities that do not meet qualifications traditionally deemed necessary for successful futures trading, such as storability. However, agricultural commodities that lack this characteristic comprise a significant share of total agricultural output. One would expect that producers of nonstorables could potentially benefit from forward pricing mechanisms just as producers of storable commodities do. Support for this reasoning is suggested by the evidence of successful futures contracts for nonstorable commodities such as live cattle, feeder cattle, hogs and potatoes.

Accordingly, there is a perceived need for a theoretical construct that can accommodate agricultural commodities that do not fit into the existing theoretical construct for storables. Without such a theory, evaluation of market performance is hindered and interpretation of any empirical analysis is limited to each case study. Since generalization of results is not justified in the absence of a unifying theory, progress with the futures research for nonstorables has been impeded.

A generalized futures theory could offer a systematic means of evaluating the efficiency of existing futures contracts in terms of the benefits they generate to producers, as well as provide a reference for judging overall economic performance. Such a theory could be used to identify potential benefits from creating new contracts for commodities not currently traded. Furthermore, a generalized theory for nonstorables would provide a basis for developing various empirical models useful for predictions. Finally, a guiding theoretical construct is needed to fully analyze the basis since successful hedging strategies depend on an understanding of the relationship between the cash and futures markets.

The purpose of this paper is to offer a theoretical construct that is general enough to handle all types of commodities, from those with a long storage life, such as corn, to those which are highly perishable, such as fresh beef. As in the case of storables, this theory will be set forth in terms of the basis. In particular, identifying and analyzing the relationship between commodity characteristics and basis performance will give insight into the functioning of forward pricing mechanisms in the absence of perfect storability.

In order to begin this investigation, an orientation towards the concept of storage will be useful, extended by an examination of the similarities and differences existing between storables and nonstorables. In addition, a brief review of the functions of a forward price mechanism, such as a futures contract, will set the stage for developing a theoretical structure for all types of agricultural commodities.

Concepts of Storage

The concept of storage can be viewed as an extension of the purely competitive model. That is, incorporating the time dimension into the traditional model yields a temporal allocation model that is operationalized by the potential for storage. Conceptually, the temporal allocation model is analogous to the spatial equilibrium model, but markets are separated by time periods rather than by regions. In the purely competitive model, market participants acting in their own self interest generate the forces which bring about a competitive price. Using the Pareto criterion, this price can be shown to be optimal in conveying allocation signals since the competitive price reflects the marginal value of the product.

Theoretically, the prices arising out of the competitive process in a temporal allocation model reflect the commodity's marginal value in each time period. Competitive forces insure that the prices among time periods will differ only by those costs associated with the various dimensions of storage; hence, it is these costs that the basis reflects. The competitive pricing system optimally allocates product across time, just as a competitive system optimally allocates product among regions in the spatial equilibrium model.

Both the temporal and spatial equilibrium models rely on the potential for arbitrage to guarantee that the competitive process operates properly. In the case of storable commodities, deviations from the marginal conditions are corrected since dealers can take advantage of market distortions by moving the product into and out of storage. Market participants have expectations about supply and demand conditions for future periods. Through the process of individuals acting on these expectations within the competitive market place, prices tend towards a competitive equilibrium.

A great deal has been written in this area of theory concerning the temporal allocation of storable products. An important topic deals with examining how pricing institutions, such as forward prices and futures contracts, aid in facilitating the movement of goods in and out of storage. This same problem has been viewed in terms of the supply and demand for storage. A comprehensive discussion of the literature is included in the next chapter.

A different perspective is needed when futures contracts are considered for nonstorable commodities. Conceptually, futures contracts exist for commodities representing time or form transformations. For a storable commodity going through a time transformation, there is a clear relationship between the cash and futures market that reflects the cost of storage. In the case of a form transformation, such as feeding out cattle, there is a relationship between the futures price of the transformed product (slaughter weight cattle) and the cash price of the untransformed product (feeder cattle). Under competitive conditions, the basis corresponding to a form transformation should reflect the cost associated with completing the transformation.

Commodity allocation through time, form and space is directed by prices in a competitive system. In a temporal model, forward pricing mechanisms affect allocation in two fundamental ways. First, forward prices provide signals for product movement in and out of storage. Secondly, these prices may also influence production decisions. In the case of nonstorable commodities, this second factor is of greater importance because the ability to move a product through time may be severely limited or even nonexistent for some commodities. For example, fresh beef must be consumed shortly after slaughter. A closer examination of the functions and need for a forward pricing mechanism follows in the next section.

Functions of Forward Pricing Mechanisms

Ideally, forward pricing mechanisms provide several functions. Two functions of particular importance discussed in this section are that it acts to provide price signals to allocate products over time and that it reduces producer's price risk. In addition, forward pricing institutions provide producers with marketing alternatives by offering an outlet for product delivery. These pricing institutions assimilate market information, thereby decreasing search costs and increasing the effectiveness of the allocative mechanism.

Forward prices give an indication of product value at some future date. In terms of allocation, this type of information influences the usage of current holdings of stocks. Relatively high future prices quoted for a forthcoming season for a storable commodity such as corn may cause current corn supplies to be put into storage until next season. For nonstorable commodities, these price signals have a different impact. For instance, a cattle producer may postpone a slaughter date by a few days or weeks by slowing down the steers' rate of gain or marketing at a heavier weight if relative prices among time periods favor this strategy. However, the cattle feeder's ability to manipulate the marketing date is relatively limited when compared to a producer of a storable commodity.

For commodities going through a form transformation, price signals are more important in influencing production decisions than allocating existing supplies. Forward or futures prices have the greatest potential impact before the production process has been initiated. For example, if the futures price of fed steers six months in the future is greater than the current feeder cattle prices and the cost of feeding an animal out, then a cattle producer may respond by increasing production. However, supply response is limited by other factors such as fixed inputs and biological constraints. For instance, favorable future pork prices may cause an increase in pork production, yet there is a time lag in the increase since the hog reproduction cycle is not instantaneous. In terms of financial limitations, feedlot operators may not respond to low future beef prices by reducing cattle on feed because they want to spread their high fixed costs over as many output units as possible.

From a broader perspective, a forward pricing institution is beneficial in its allocative function because it promotes an efficient distribution of output over time periods. A forward pricing mechanism acts as a market place in which market participants temporally allocate product through time up to the point of highest return. Ideally, this competitive process yields an allocation in which the product's marginal value is equalized across time. Therefore, the resulting allocation is desirable in an economic sense.

A second function of a forward pricing mechanism is that it helps producers reduce their price risk. The agricultural sector is typically characterized by substantial price fluctuations. While domestic demand for many agricultural goods is relatively stable, export demand may be significantly influenced by foreign policy and exchange rates. Both of these factors can cause appreciable price movements. From the supply side, uncontrollable and unforeseeable factors such as weather affect aggregate output and hence prices. Finally, the relatively long production period associated with most agricultural products increases price uncertainty for the producer since the accuracy of predicting a future price decreases with the length of time until marketing. Accordingly, price risk arises from not knowing what output price will prevail at the future date when the production process is complete.

A reliable forward pricing mechanism can act to decrease price risk by providing a mechanism for setting prices for future delivery. One alternative is for the producer to establish a forward contract with a buyer specifying the price or formula for calculating the price. By this means, a producer can lock in a price for his output at some time prior to harvest. Another alternative is for the producer to hedge his cash position in the futures market. Thus, a forward pricing mechanism is beneficial from a microeconomic perspective because it can reduce the price risk component of a farmer's operation. Furthermore, these cost reductions eventually manifest themselves as lower output price at the aggregate level and therefore the forward pricing mechanism is also beneficial in a macroeconomic sense.

Several functions performed by forward pricing mechanisms have been identified. In addition, there is a great deal of interest in the process of price discovery associated with these mechanisms. In the case of futures markets--the most extensive and organized forward pricing institution--the trading process incorporates expectations from a wide range of participants. These agents, including individual producers, merchants, speculators, etc., use various information sources to form expectations on future demand and supply conditions. Through the market these expectations are translated into futures price quotes. The fundamental workings of futures markets are described in the following section.

Futures Markets

A futures market is an organized market in which contracts specified for some future delivery date are traded on an open exchange. These contracts are specified in terms of a commodity's quality, quantity and delivery location. For instance, a corn futures contract traded at the Chicago Board of Trade is 5,000 bushels of number 2 yellow corn. The purpose of specifications is to facilitate trade by insuring contract uniformity. Discounts or premiums from a contract price can usually be arranged if a delivered product deviates from the contract specifications within defined limits.

Futures contracts are legally binding and traded by qualified brokers that are members of the exchange. The primary difference between a forward negotiated contract and a futures contract is that the former usually involves the actual delivery of the commodity. In contrast, 98 percent of all futures contracts are settled without delivery. Traders, acting through the member brokers, buy or sell contracts and a clearing house keeps a record of the brokers' net positions. To enter the market, a trader can establish a long position (contract to buy) or a short position (contract to sell). A trader terminates his position by reversing the initial futures commitment. For example, a trader who buys three soybean contracts and then sells two contracts has a net long position of one contract.

The basic purpose of a futures market is to provide members with the facilities to trade contracts. The trading activities are closely monitored to see that the exchange's rules are adhered to. These rules are intended to facilitate the trading process and specify such things as the hours that trading will take place and the daily price movement limits. In addition, the extensive communication system associated with futures exchanges promotes the trading process by quickly disseminating market information to the public.

Those who trade commodity futures represent a wide range of occupations, but can be classified into two general categories according to their intent in trading. One group is known as speculators since they speculate on price movements. These traders take on the risk of price fluctuations in hopes of a return. In percentage terms, the potential return on their investment can be phenomenal since only a small fraction of the contract's value, i.e. the margin, must be put down in order to trade. Of course, the speculator also subjects himself to potentially significant losses in the event that price moves against his favor. A speculator's position may be long or short, or it may change from one to the other. The second type of trader is known as a hedger and he attempts to reduce the price risk that he is subjected to in the cash market by hedging his position in the futures market. The textbook example is for the hedger to take an equal and opposite position in the futures market than is held in the cash market. Since prices in the cash and futures markets tend to move together, losses in one market tend to be offset by gains in the other market.

For example, consider an elevator operator who has an inventory of corn which he is planning to sell at some future date. To hedge, he would sell a futures contract so that his long position in the cash market is offset by a short position in the futures market. A price fall would decrease the value of his inventory, but would also result in a gain in the futures market. Alternatively, a price rise would cause a gain in the cash market and a loss in the futures market. The degree to which the gains and losses offset each other--which measures the effectiveness of the hedge in reducing risk--depends on the relationship between prices in the cash and futures market. This relationship, defined in terms of the futures price minus the cash price, is called the basis and is discussed in the following section.

Basis Concept

A basis can be broadly defined as the difference between two prices. This difference reflects the difference in a product's time, form or location qualities. For instance, the basis for the corn price in Chicago and Kansas City represents a location basis and reflects the transfer cost between these two locations. With respect to futures markets, the basis is the futures price minus the cash price. There is a basis corresponding to each delivery month, such as the September or November soybean basis. In addition, the term basis can be used to refer to the difference in the cash price of one commodity and the futures price of another. For instance, there is a basis for the cash price of feeder cattle and the futures price for live cattle.

For a hedger, the basis is critical to successful use of the market. It is this variable, rather than absolute price levels that determine the returns to a hedged position. Essentially, the hedger is averting the price risk he would be subject to if he only held a cash position by taking an offsetting position in the futures market. There are underlying economic factors which make futures and cash prices move jointly. If basis variability is less than cash price variability, a producer can reduce risk by placing a hedge.

From an economic standpoint, the basis is of primary importance because it is an index for judging market performance. A normal basis should reflect any time, form or location differences. In other words, price differences should reflect the value added by these three dimensions. A basis that is too large or small indicates a malfunction in a market that the competitive process fails to correct. In order to identify problems, it is first necessary to have expectations about how the basis should perform.

Problem Statement

A great deal of research has been devoted to analyzing how the time dimension affects the basis for storable commodities. This work has led to a generally accepted theory of basis determination. Lacking in the literature is a comprehensive treatment of futures markets for all types of commodities, beyond the case of storables. There is a perceived need for a fundamental theory of futures markets which can have a broad application for commodities with different time and form characteristics.

Objectives

(1) Develop a theoretical framework for classifying commodity futures according to a) whether they represent time or form transformations, and b) commodity characteristics that limit arbitrage, the market adjustment mechanism.

(2) Develop an analytical framework to analyze the competitive adjustments that relate the cash and futures markets.

(3) Identify factors that can limit arbitrage and hypothesize their affect on basis performance.

(4) Develop criteria for judging basis performance based on economic considerations and hedging effectiveness.

(5) Develop an empirical model using cross commodity data in order to investigate the relationship between basis performance and commodity characteristics.

Scope

In the present analysis a theoretical model of basis determination is developed that is generalized enough to include both storable and nonstorable commodities. The emphasis is on relationships between cash and futures markets that represent both time and form transformations. The spatial dimension which influences basis patterns is not explored. The entire analysis is set forth in the context of arbitrage as the competitive mechanism that integrates the cash and futures markets.

Neither the theoretical model nor its empirical counterpart offer a means of determining price levels in the cash or futures markets. Rather, the model is used to investigate the basis levels between these markets. While expectations are fundamental to price determination, this basis model does not rely on the formation of expectations to drive the model.

Alternatively, in the theoretical model potential arbitrators trade on observed conditions between the two markets. Two unobservable factors that make up the basis, the convenience yield and the risk premium, are recognized but not explicitly measured. In addition, the model does not accommodate multiperiod storage functions.

Nine agricultural commodities over a fifteen year period are included in the empirical investigation. Basis models representing two, four and six months from contract maturity are examined. Market performance is gauged by the variability in the basis since a reliable measure of what a basis value should be can not be accurately calculated. Furthermore, it is the variability in the basis, or basis risk, that is important to the returns to hedging. The empirical model is useful to predicting how variability is affected by commodity and market characteristics. Since performance is viewed from a macroeconomic perspective, alternative hedging strategies are not compared and the returns to hedging are not empirically measured.

Overview

A summary of basis theory, the literature review and discussion of arbitrage are set forth in Chapter II. In Chapter III, where the theoretical model is developed, an analytical framework that describes the adjustment process between the cash and futures markets is examined. In Chapter IV an empirical model is developed in which a measure of basis performance is specified and observable factors that influence arbitrage potential are identified. Data and estimation procedures are also discussed in length. Chapter V includes the results of the empirical model. Chapter VI follows with further investigation and simulation of the results while conclusions are included in Chapter VII.

CHAPTER II
REVIEW OF LITERATURE

A summary of basis theory is presented at the beginning of this section accompanied by a review of pertinent literature. Specifically, the purely competitive model of basis theory is set forth, extended by the theory of storage and futures trading. Next, a behavioral assumption is identified that acts to integrate the cash and futures markets. By arbitrating, market participants provide the economic forces necessary to successful functioning of the market. It is shown that limitations to this mechanism affect basis performance.

Basis Theory

A thorough treatment of the theory of basis determination for perfect markets can be found in Bressler and King (1978). Under the competitive assumptions of 1) perfect knowledge for buyers and sellers, 2) free entry, and 3) rational behavior, the fundamental basis theory is demonstrated for three broad categories of product transformation, namely, space, time and form. In Bressler and King, basis determination for each dimension is first examined separately, then the analysis is extended to models which incorporate two or more of the transformations simultaneously. A brief summary of fundamental basis determination follows.

The spacial equilibrium model is simplified by considering two regions with given supply and demand conditions. First, market equilibrium is derived for each market separately, yielding regional prices in the absence of trade. Next, assuming unrestricted trade, equilibrium is reached over both markets by product movement from the area with a lower regional price to the higher priced region. This product migration occurs since arbitrators can buy in the lower priced region and sell in the higher priced region, thereby profiting from their actions. This process causes increased demand in the exporting region and, hence, upward pressure on price. Simultaneously, the influx of product into the importing region causes downward pressure on price. The process continues as long as there is a profitable return to arbitrage. In the final outcome, price between the two regions differs only by the transfer cost between regions. That is, the basis between the two regions will never exceed the transfer cost under the above assumptions (Bressler and King, 1978).

Another important aspect of spacial equilibrium concerns the allocation of supply points among competing markets when production is dispersed. In this model, the relevant basis is the difference between the market price and the price received at the site of production. Under competitive conditions, the site price, or net price received by the producer, is equal to the market price less transfer cost. Thus, the closer a supply point is to the market, the higher its site price will be. A market boundary is defined as points between competing markets where the site price to either market is equal. Therefore, a producer located on a market boundary is indifferent to which market he supplies. By acting to maximize net returns, producers provide the forces which link prices within the competing regions.

A second dimension of market price involves differences in commodity form. For instance, a raw product such as milk can be transformed into a variety of finished products like fluid milk, cheese or yogurt. The allocation of raw product among competing uses is governed by price relationships among alternative forms, given the physical range of product characteristics. In this instance, a basis can be defined as the difference between the value of the raw product and the price of the final product adjusted for raw product equivalence. Just as the basis in the spatial model reflects transfer costs, the basis in the form model reflects processing costs. Under perfect market assumptions, the net value of raw product is equal across all product uses. If this were not the case, processors could profit by shifting production patterns. For example, a basis which exceeded processing costs would encourage entry up until the point where excess profits were eliminated. Therefore, processors' actions should insure a price structure that is consistent with costs.

The above principles outlined for the space and form dimensions can also be applied to markets which are differentiated with respect to time. In this model, the commodity is moved through time as opposed to space or form. The analogy to transfer or processing costs is storage costs in the temporal model. There are two factors which complicate the analysis of temporally separated markets. First, there is asymmetry in the potential for product movement because future production cannot be brought back to the present time period. Secondly, uncertainty, or the absence of perfect knowledge, enters the analysis since future supply and demand conditions are unknown. A review of the literature concerning the theory of storage is presented in the next section.

Theory of Storage

The theory of storage can be analyzed in terms of the demand and supply of storage. The equality of these two functions yields an equilibrium storage price and quantity. The demand for storage is a decreasing function of price, that is, as the cost of storage increases, the quantity of storage space demanded falls. The storage supply function is discussed below.

Many economist have contributed to the supply of storage theory, including Working (1948), Cootner (1960), Kaldor (1939), Brennan (1958), and Telser (1958). The supply curve is derived from the marginal cost of storage. The total marginal cost is comprised of several components, including physical outlay, convenience yield and risk premium. Obviously, there is a physical outlay required to carry inventories. The physical outlay represents costs associated with the physical care and handling of a commodity in storage and include factors such as the cost of storage facilities and damage insurance. This type of cost is relatively straightforward to calculate.

Kaldor (1939) introduced a second component in the total net marginal cost of storage known as the convenience yield. The convenience yield is a negative cost, or benefit, of carrying inventory. For example, a processor benefits from maintaining some threshold of inventory, even if prices are falling, so that he can avoid interrupting the production process. Such interruptions can be costly for plant operations and customer relations. Therefore, when stocks are low, the convenience yield can be used to explain an inverse carrying charge, which is an empirically observed situation where a spot or near futures price exceeds a distant futures price. It is contended that when stocks are low, the benefit from the convenience yield exceeds the cost of the physical outlay, thereby resulting in an inverse carrying charge. Thus, some storage will occur even when the market price spreads do not fully cover the cost of storage. Furthermore, the convenience yield is a function of stock levels and is expected to decrease rapidly as stocks increase.

Brennan (1958) extended the theory by adding a risk premium to the other components of the cost of storage. There is price risk inherent in carrying stocks. Assuming risk aversion, holders of stocks must be reimbursed with a premium for carrying inventory. Since risk increases with the amount stored, the risk premium is thought to be an increasing function of stocks. Thus, in the Brennan model, the net marginal cost of storage is equal to the physical outlay plus the risk premium minus the convenience yield. Telser (1958) utilizes the same construct in analyzing the storage of cotton and wheat, while Weymar (1966) includes a convenience yield and risk premium in an analysis of the cocoa basis. Malick (1985) empirically estimates these effects for frozen orange juice. However, since the storage supply function cannot be empirically observed, it is not surprising that controversy surrounds the theory with respect to the risk premium (Gray, 1972).

The marginal return from holding stocks is the change in price over the storage period. Since the future price is not known a priori, inventory holders must make price expectations, P^*. The expected marginal return is thus expected price minus current price, $P^* - P_t$. The optimal holding of stocks is the inventory level where net marginal cost equals expected marginal revenue, assuming that costs are known.

The theory of storage outlined above is not contingent on the existence of a futures market. However, a futures market offers an organized exchange for dealing in commitments that have deferred delivery. Working (1948, p.2) discusses the theory of futures markets emphasizing its "exceptional convenience and economy of transaction." Other economists have analyzed the theory of storage in terms of the equilibrium between the cash and futures markets, as discussed below.

In "The Simultaneous Determination of Spot and Futures Prices," Stein (1961) creates an equilibrium model for spot and futures prices in the case of storable commodities. He first develops a theory for holding stocks to obtain the supply of hedged and unhedged storage. He then derives a curve which gives the combination of spot and futures prices that equilibrates the demand and supply of storage. Next, he derives a curve that equilibrates the demand and supply of futures contracts. Together, these curves create a simultaneous equilibrium system. With this model, one can obtain qualitative results of how the basis adjusts to variations in the demand and supply for current production, and changes in expected prices. While holding price expectations constant, Preston and Yamey (1960) consider models based on alternative trader compositions, such as hedgers, speculators, and merchants, who respond differently to price changes. They conclude that only the general direction of equilibrium adjustment for stock and consumption levels can be determined.

Previous Literature

In conjunction with the storage literature already set forth, the research relevant to the present analysis must include treatment of nonstorable commodities. Two general areas in the nonstorable literature pertinent to this analysis are price forecasting and market efficiency; and hedging and basis relationships for nonstorables.

Because nonstorable commodities can not be carried across seasons, they must be analyzed in a different framework than storables such as grains. Commodities that do not meet the qualifications of storability include cattle, hogs, eggs, iced broilers, pork bellies and potatoes. In the literature, these commodities are referred to as nonstorables although the storage potential among them varies. The bulk of nonstorable research has been directed towards cattle and hogs since these contracts have been traded in significant volume for a relatively long period of time.

Price Forecasting and Efficiency

Much of the nonstorable research has been focused on the futures market in its price forecasting or forward pricing role. Tomek and Gray (1970) emphasize that the primary function of futures markets for nonstorables is establishing forward prices, as opposed to allocating inventories. Many empirical studies have been conducted to evaluate the pricing efficiency of futures markets using different methods and criteria for judging performance. The results of such research have implications about how well futures markets function in incorporating market information.

Leuthold and Hartmann (1979) appraise the efficiency of the futures market as a price forecaster for hogs. They compare futures prices to results from econometric forecasting models. They find the econometric model to be more efficient than futures prices at predicting subsequent cash prices. Using a similar approach, Just and Rausser (1981) compare futures market prices to large scale econometrically based forecasts for both storable and nonstorable commodities. While their results are mixed, they find that on average, futures prices perform relatively better than the econometric forecasts. However, for livestock they find that some econometric forecasts outperformed the futures market for forecast accuracy.

Leuthold (1974) evaluates futures prices as predictors for cattle prices using current cash prices as the norm with which to base his comparison. He finds that the cash price is a more accurate indicator of subsequent cash price than is the futures price. Marquant (1979) compares futures prices to various governmental, university and commercial outlook reports and finds futures prices to be superior forecasters of cattle and hog prices in terms of timeliness and accuracy. Martin and Garcia (1981) find live cattle futures to have inadequate forecasting performance under several alternative criterion, while they find that hog futures perform better than cattle futures. They conclude that "the analysis does not support the contention that these futures markets are agencies for rational price formation" (p. 209).

Market efficiency is closely related to price forecasting since both of these dimensions relate to how information affects price formation. Samuelson (1965) demonstrates mathematically that prices generated in an efficient market fluctuate randomly. In an efficient futures market, prices should quickly reflect new information. Assuming new information occurs randomly, the sequence of futures prices should also be random. Therefore, a test of the efficiency of the futures market is whether or not futures prices follow a random walk. This argument of unbiased price changes parallels Muth's rational price formation model.

Many studies investigating the efficient market hypothesis have included nonstorable commodities (Cargill and Rausser, 1975; Mann and Heifner, 1976). Helmuth (1981) develops a systematic trading technique to predict price movements in live cattle futures. If the futures market is truly efficient, that is, price changes occur randomly, then no mechanical trading method can be employed to increase trading returns. Helmuth's (1981) results support Martin and Garcia's (1981) ascertain that cattle futures defy the rational price formation hypothesis. He concludes that

> . . . the live cattle futures market is not operating as an efficient price discovery mechanism and that this market is operating with a consistent, systematic, downward bias. (p. 356)

Palme and Graham (1981) contest Helmuth's findings and argue that his results are based on poor analytical techniques. In response to this controversy, Kolb and Gay (1983) apply a different methodology to appraise the efficiency of the cattle futures market. They find no evidence of a systematic downward bias nor any reason to suggest that the cattle futures market is inefficient.

Summarizing, the research concerning pricing efficiency in nonstorable futures markets is inconclusive. Research in this area has been directed towards identifying whether or not inefficiencies exist, rather than analyzing why they may exist. A rigorous theoretical model has yet to be developed to explain what may cause malperformance in the price determination process.

In addition to the work done in evaluating the efficiency of nonstorable futures markets, others have focused on the volatility of futures prices. Samuelson (1965) hypothesized that futures price variability increases as the maturity date approaches. Miller (1979) investigates this hypothesis for live cattle and her results support the hypothesis of increasing variance over time.

Anderson (1985) tests Samuelson's hypothesis for a variety to markets, including storable and nonstorable commodities. He tests this maturity affect against what he refers to as the state hypothesis. According to the state hypothesis, futures price volatility is highest when the greatest degree of demand and supply uncertainty is resolved. In agriculture, these periods when large amounts of uncertainty are resolved follow a seasonal pattern. Using both parametric and nonparametric testing procedures, Anderson finds that both seasonality and time until maturity affect price volatility, with seasonality being the dominant force. Anderson's results influenced the empirical design of this research, in particular, for decisions concerning time aggregation and seasonal adjustments.

Hedging and Basis Relationships

Another area in the literature on nonstorables is concerned with hedging and basis relationships. Topics in this general area include determination of optimal hedged positions, consequences associated with alternative hedging strategies, basis risk and basis determination. Some of the analytical techniques used in this research are common in the investigation of both storables and nonstorables. The relationship between the cash and futures market is the fundamental element underlying all research in this area.

Ward and Fletcher (1971) develop a generalized model for determining optimal futures and cash market positions in which the outcome depends on risk and income trade-offs. The model is generalized enough to handle short and long hedging, as well as speculation. In the analysis, the transformation costs associated with live cattle are treated the same as storage costs for storable commodities. Using a similar portfolio approach, Heifner (1972) determines the optimal hedging levels for cattle feeding for five market locations. He finds location, grade and sex of fed cattle to have minimal influence on hedging effectiveness.

Studies pertaining to a wide variety of nonstorable commodities have been used to evaluate hedging effectiveness. Tomek and Gray (1970) consider the consequences of production period hedging by examining the variability of cash and futures prices. For potatoes, they find the prices of distant futures to be less variable than cash prices. Therefore, they suggest that potato producers can hedge as a method of stabilizing their incomes. Using a portfolio model, Peck (1975) demonstrates that hedging can stabilize revenues for egg producers. She considers hedging for the period of time after the production decision is made but before marketing. The results show that optimal hedging can significantly decrease producer risk.

Brandt (1985) provides an example of hedging effectiveness for the hog industry. He demonstrates that information from forecasts can be combined with hedging strategies to reduce risk to producers and first handlers. Brandt compares results under alternative forecasting methods and suggests that composite forecasting may be preferred to a single forecast approach.

Others have considered the effect of basis variability on the returns to hedging. Bobst (1979) examines the effect of location basis variability for southern markets. He compares the variances of hedging revenues for three Southern markets to that of Omaha. Bobst finds significant differences for choice steers but no significant differences for hogs in these markets. He concludes that location basis variability may be an important factor affecting hedging returns to southern cattle producers. Carter and Loyns (1985) consider basis risk for hedging Canadian cattle while Ward and Schimkat (1979) look at the basis risk associated with hedging Florida feeder cattle. Both of these studies indicate that basis variability can make hedging ineffective as a risk shifting device.

Vollink and Raikes (1977) examine the delivery period basis for live cattle and find that frequently the basis values exceed the estimated transaction costs of arbitrating. They suggest that speculators' price expectations account for a sizable percentage of this basis variation. Garcia, Leuthold and Sarhan (1984) analyze the basis risk for midwestern livestock markets by decomposing the basis variation into systematic and unsystematic components. They define basis risk as the variance of the random component of the basis over time. Their results show that this random variability in the basis is influenced by factors related to the flow of new information to the market. Furthermore, they do not find strong evidence that basis risk changes over the contract life.

In a similar vein, Castelino and Francis (1982) analyze basis volatility over the life of commodity futures contracts. They identify degree of storability, volume of existing supplies and commodity substitutability as factors having an important effect on the structural relationship between spot and futures prices. Castelino and Francis argue that since the linkage between the spot and futures market strengthens as maturity approaches, the volatility of change in the basis declines as contract maturity approaches. The authors empirically test this maturity effect using data across four commodities and find volatility to decline uniformly as contract maturity is approached. Furthermore, when looking at a fixed time until maturity across different commodities, they demonstrate that storability, existing supplies and substitutability affect the extent of basis variability. The present analysis extends this research by examining a larger cross section of commodities and including a broader range of factors that influence basis behavior.

Leuthold (1977) analyzes basis determination for live cattle. He examines the basis corresponding to the current cash price of live cattle and the futures price of live cattle. These prices reflect two different supply and demand situations that can not be related by storage. Therefore, only external factors common to the beef industry relate prices in the two markets.

In his analysis, Leuthold assumes demand is constant over the time interval considered and thus hypothesizes that the basis is a function of factors that affect supply, such as the beef-corn price ratio, cattle on feed and feeder prices. In addition, he includes cash price as an exogenous variable to adjust the basis to the price level. Therefore, this variable appears on both sides of the regression equation. Leuthold recognizes, but does not pursue, the problems associated with potential simultaneity (biased and inconsistent estimates). This aspect of the model weakens the reliability of the results. Based on his findings, Leuthold concludes that for a time period of two or more months until maturity, the basis reflects the expected change in cash price from the current time until contract maturity.

The present approach is similar to Leuthold's cattle basis analysis in that factors affecting supply are expected to influence the basis. One difference is that a measure of basis performance rather than the basis per se is used as the dependent variable. Secondly, the basis in this analysis is defined as the futures price minus the cash price of the input. Thus, in the case of cattle, the basis is defined as the live cattle futures price minus the cash price of feeder cattle.

In the present research, the choice of what basis to consider takes precedent from the work of Paul and Wesson, and Ehrich. Paul and Wesson (1967) examine the basis between cattle futures and cash feeder prices. They view this basis, minus the feed required to finish the animal, as the competitively derived market value of feedlot services. Ehrich (1969) analyzes the same cash-futures price relationship and theorizes that

> . . . under purely competitive market conditions, cash price of feeder cattle and futures prices for fed cattle will bear a relationship which is determined by costs of feeding and the level of futures prices. (p. 38)

The present analysis is an extension along the theme of this quote. In particular, the focus of this research is to see how the futures-cash price relationship is affected when purely competitive conditions are not fulfilled.

Garbade and Silber (1983) examine the relationship between the cash and futures markets for storable commodities. They demonstrate that the degree to which the cash and futures markets are integrated depends on arbitrage elasticity. Theoretically, when arbitrage elasticity is infinite, then cash and futures prices are perfectly correlated. The present study extends Garbade and Silber's orientation towards arbitrage by considering nonstorable commodities. Arbitrage potential is recognized as the critical mechanism linking the cash and futures markets. Thus, factors that affect the potential to arbitrate ultimately affect basis performance.

Arbitrage

In order to analyze how competitive markets operate, it is necessary to make certain assumptions concerning the behavior of market participants. One such presumption is that traders seek to maximize profit. Given that those involved are knowledgeable about market conditions, the above assumption implies that dealers will arbitrate when potential returns from doing so exist. Thus, arbitrage is the mechanism that brings about adjustment in competitive markets when distortions arise. Arbitrage is usually discussed in the context of trading across market regions. Yet, the same concept can be applied to trading across cash and futures markets.

An arbitrator profits by buying in a low priced market and selling in a higher priced market. This function is not only performed by those who make a profession of trading; others, who are actually involved in producing, processing or marketing commodities, are also in a position to take advantage of price distortions. For example, assume that near futures prices for oil and meal, adjusted for raw product equivalence, exceed the price of soybeans and crushing costs. A processor could sell oil and meal futures, buy soybeans in the cash market and crush them, then deliver on the futures contract. Thus, arbitrage can take on many forms and this research is specifically concerned with the arbitrator's role of integrating the cash and futures markets, for storable and nonstorable commodities.

A number of conditions must exist for arbitrage to be an effective adjustment mechanism. The most important factor in relating the cash and futures market is that a certain percentage of futures traders are hedgers.

Hedgers give substance to the futures market because they have the potential to deliver against a futures contract. Without hedgers, there is no reason for futures prices to necessarily reflect demand and supply conditions. Although very few contracts are fulfilled by delivery, it is the potential for delivery that is important.

Limitations to the effectiveness of arbitrage can be classified into two main categories, those which are market oriented and those which arise from industry characteristics. Several deterrents to effective arbitrage that relate to the functioning of the futures market may exist. One constraint is insufficient market liquidity. The first step in addressing this issue is to estimate the composition and relative share of those trading a particular futures contract (Peck, 1980; Rutledge, 1978; and Larson, 1961). Ward and Behr (1983b) develop a simultaneous equation model of futures trading in which a measure of market liquidity is shown to be affected by market characteristics such as firm number, industry concentration, price risk, government programs and perishability. Price distortions may go uncorrected in illiquid markets since a trader must incur higher costs in order to establish or close out a futures position.

A second market related limitation to arbitrage is lack of accurate price information. A basic premise of an efficient market is perfect knowledge on the part of buyers and sellers. Accordingly, the viability of the competitive mechanism declines as information quality decreases. In addition, industry structure has an impact on the competitive mechanism. For instance, in a concentrated industry with noncompetitive pricing, prices no longer reflect demand and supply conditions and the futures contract fails.

Another aspect of the futures market that may interfere with the potential to arbitrate is contract specification. If a hedger's product does not fulfill a contract definition, then in some instances he may lack the option to deliver. Ward and Schimkat (1979) evaluate the basis risk associated with hedging Florida feeder cattle with the Chicago contract that is tailored for midwest feeder cattle. Dewbre (1977) examines the potential for those in the Pacific Northwest to use midwest wheat futures contracts. Carter and Loyns (1985) find the U.S. live cattle futures to be an ineffective hedging vehicle for Canadian fed cattle. These studies emphasize that basis patterns, and hence hedging effectiveness, can be greatly influenced by contract specifications. Furthermore, the tradeoff between a contracts fit and market liquidity must also be considered.

The limitations discussed above are all related to technical features that may be present for a futures contract. In some instances, these problems can be corrected through intervention. For example, contract terms can be redefined in order to increase trading volume and liquidity. In other circumstances, a contract may simply fail because it lacks sufficient commercial interest. For instance, if an industry becomes highly concentrated and price volatility diminishes, the economic need for hedging disappears.

The second major category of limits to arbitrage involves industry characteristics that can not be adjusted with market intervention. These characteristics are inherent to production techniques and biological processes and thus independent of the institutional or market setting. One such limitation involves capacity constraints. Many agricultural industries are characterized by significant fixed investment. Instead of smoothly rising cost curves, total costs rise in stairstep fashion (Bressler and King, 1978). Output can be increased at closely the same per unit cost over a certain range, then, when full plant capacity is utilized, substantial investment in new plant or machinery is required to further increase production. For example, by increasing the use of variable inputs, a soybean producer can increase the crushing rate at approximately a constant cost rate up until the plant is used to full capacity. To increase production beyond this level, a new plant must be built, and accordingly, total per unit costs will rise considerably.

This type of cost structure causes inelastic supply responses over at least some levels of output. These supply inelasticities in turn influence the effectiveness of arbitrage. Distortions can arise that go uncorrected since the benefits from arbitrating are not great enough to cover the costs necessary to increase the fixed component of operations. For instance, it is typical for crush margins to widen at harvest time when plants are operating at or near full capacity. The crush margin narrows during other times of the year when competition among processors squeezes profits to a minimum.

From an economic standpoint, it can be argued that the differences in the pricing of processing services do not necessarily indicate imperfect competition. If opportunity costs are also considered, then the economic cost of processing differs at various times of the year. That is, total processing costs are highest at peak demand periods because of the added opportunity cost involved. Although capacity constraints definitely limit the potential to arbitrate, one must use caution in interpreting the implications of prices which are above transformation costs.

A second industry characteristic that can limit arbitrage originates from the biological nature of production processes in agriculture. For many commodities, time is a necessary ingredient for completing a form transformation. This factor is relatively unimportant in some transformations, such as crushing soybeans into oil and meal. However, in many commodity transformations, such as changing feeder cattle into fed cattle, time is required to complete the process. The necessity of time leads to production inflexibilities that in turn restrict arbitrage. In most instances, the potential for arbitrage does not exist prior to completion of the transformation process, for a particular producer. For instance, a farmer with immature field corn cannot take advantage of a nearby futures price that greatly exceeds his production costs because he has nothing to deliver against the contract. He can only act on futures contracts that mature simultaneously or later than his harvest date. Ward (1970) discusses the limitations imposed by the time element in transformation process for cattle.

Two other commodity characteristics, seasonality of production and perishability, also relate to the time dimension. Frequent harvest periods and storability both enhance marketing flexibility and hence aid in the competitive adjustment process. In the aggregate, the limitations imposed by the time input are much less restrictive if a commodity is produced continuously throughout the year. Such production processes yield a flow of output to market, as in the case of broiler production. At any given point in time, there is some percentage of producers who are in a position to deliver against a futures contract. Therefore, the potential exists for correcting price distortions so that the cash and futures markets are more closely linked.

Storability also adds flexibility to commodity marketing. When storage is feasible, a producer or handler has the option of when to dispose of the product. Relative prices among time periods influence current consumption and storage rates, while arbitrators maintain price differences consistent with storage costs. In contrast, the relationship between transformation costs and prices is weaker for perishable goods. For such commodities, current demand and supply conditions are not linked by the storage function. Because quality characteristics deteriorate rapidly for perishable goods, market participants do not have the option to buy and sell between time periods.

Another trait characteristic of agriculture that reduces arbitrage potential is production uncertainty. A significant portion of agricultural commodities relies on uncontrollable inputs, such as weather, for the production process. These uncontrollable--and unpredictable--inputs lead to uncertainty about a producer's final output. A producer's hedging strategy may not be fulfilled if his output intentions are not realized. For instance, assume a farmer places a short hedge in the spring on an anticipated yield of 100 bushels of corn. Late summer drought conditions result in an actual yield of 60 bushels of corn. This producer's actual hedge differs substantially from what he intended because his final output is significantly less than anticipated. In essence, he has unintentionally become a specutlator on the unrealized prodution. If he had hedged 100 percent of expected output, then his option to deliver his own crop against the futures contract is mitigated. Therefore, the potential for hedgers to arbitrate is reduced by production uncertainty. Furthermore, production uncertainty affects hedging strategies. A producer may hedge much less than his optimal level since he must use conservative yield estimates.

Summary

In the context of perfectly competitive conditions, the fundamentals of basis determination were briefly reviewed for the space, form and time models. The temporal model was then elaborated with a summary of major developments in the theory of storage. Literature pertaining to basis determination for nonstorable commodities was also discussed. Arbitrage was identified as the force that integrates the cash and futures markets. Factors that can potentially decrease the effectiveness of arbitrage were explored and shown to be related either to specific commodity characteristics or technical features of the futures market.

CHAPTER III
THEORETICAL MODEL

In this chapter the theoretical model of basis determination is developed. First, time and form transformations are discussed and a measure of basis performance is identified. Following, an analytical framework is constructed that will be used to examine the adjustment process in the cash and futures markets corresponding to alternative basis levels. Finally, the stringent assumptions underlying the perfectly competitive market will be systematically relaxed and, using the analytical framework, the affects on basis performance can be theorized.

Time and Form Transformations

In marketing theory, three qualities are recognized that can add to a product's value--namely, time, form and space. In order to narrow the scope of study to manageable proportions, the ongoing analysis will focus on time and form transformations. The spatial dimension will be accounted for in the empirical investigation, however, no attempt will be made to evaluate or analyze the level of transfer costs.

Conceptually, one can consider a product prior to a time or form transformation as a principal input and the resulting transformed product as output. For example, a feeder steer is an input for a slaughter weight steer. Alternatively, field corn put into storage at time t is an input for corn consumed in period t+k. As discussed in the preceding chapter, under theoretically ideal competitive conditions, the price difference between input and output should equal the cost of transforming the product with respect to time and/or form.

Accordingly, the relevant basis to consider in analyzing the futures-cash basis is the difference in the cash price of the input and the futures price of the output. It is this price difference that is important because it reflects the value added by the transformation. This value adding function may represent a form transformation, in which case the physical qualities of the input differ substantially from the output, such as feeder pigs and live hogs, or soybeans verses soybean oil and meal. In a form transformation, the physical qualities of the output represent the preferred or more useful form of the commodity. In a time transformation, the physical characteristics of the input and output are the same. In this situation, the basis reflects a time value generated by holding stocks for deferred consumption.

Table 3.1 shows examples of commodities going through time or form transformations. The left hand column symbolizes the cash price in the input market while the right hand column designates the futures price for the output. The center column shows the type of transformation and some of the factors required to complete the transformation process. Subscripts designate time.

Essentially, the conventional theory of storage is exemplified by the first commodity in Table 3.1, wheat, that goes through a time transformation from period t to t+m. The costs associated with this transformation include physical outlay, convenience yield and the risk premium. The basis, that is, the right hand column minus the left hand column, should equal the total storage costs under ideal competitive conditions. The actual adjustment process leading to such an outcome will be discussed in the analytical framework section.

Soybeans offer an example of a commodity that can be transformed with respect to time or form. In the form transformation of crushing soybeans into oil and meal, there is no significant physical or biological time requirement in performing the crush process. Conversely, in the case of transforming a feeder steer into a slaughter weight steer that meets the specifications of a live cattle futures contract, time

Table 3.1. Time and Form Transformations.

Cash Price (t) of input	Transformation	Futures Price (t+m) of output
Wheat (t)	Time Transformation storage cost: physical outlay convenience yield risk premium	Wheat (t+m)
Soybeans (t)	Time and Form Transformation storage (optional) processing cost	Soybean Oil and Meal (t+m)
Soybeans (t)	Form Transformation processing cost	Soybean Oil and Meal (t)
Feeder Calves (t)	Form Transformation cost of feeding out to market weight	Live Cattle (t+m)
Seed Corn (t)	Form Transformation production costs	Corn (t+m) (storage option)

is a necessary ingredient. However, in a form transformation that requires time, the time dimension, in and of itself, does not add to market value, as it does in the case of a time transformation. The distinction as to whether time enters the transformation as a value adding function or a physical requirement should be made clear.

The value added by time and form transformations can be separated conceptually even though the opportunity to perform the transformations simultaneously may exist. For instance, soybeans in period t can be stored and crushed in order to arrive at oil and meal in period t+m. Therefore, in this example, the output in t+m includes both form value and time value components. Using this conceptual framework, transformations can be categorized as shown in Table 3.2.

Returning to Table 3.1, the last row represents the process of transforming corn seed stock into field corn. This form transformation is conceptually the same as the feeder-slaughter weight steer transformation, even though corn is a storable commodity and fresh beef is nonstorable. In the present study the storable-nonstorable dichotomy emphasized in the literature has minimal analytical usefulness. The pertinent classification, as shown in Table 3.2 is based on the type of transformation. Therefore, the

Table 3.2. Transformation Categories.

Type	Description
1) time transformation	Physical characteristics are constant over the time interval.
2) form transformation	Physical qualities of input differ from that of output.
3) form transformation requiring time	Time is a necessary factor in completing the form transformation but time does not add market value per se.
4) time and form transformation combined	Physical characteristics change and time adds value.

distinguishing characteristic between corn and cattle in the present example is that the potential for time transformation following the form transformation exists for corn but not for fresh beef. That is, corn may be stored after harvest whereas fresh beef must be consumed shortly after slaughter. In addition, the issue of whether or not a form transformation requires time is important because this characteristic affects a producer's ability to respond to prices.

The rationale for classifying commodities according to the value enhancing transformation is that under the assumptions of perfect competition, the marginal return from transforming a product will equal the marginal cost of transforming. If the marginal return is less than the associated costs, then the transformation should not be initiated. In the other direction, competition drives the transformation margin (the basis) to a level consistent with cost. The adjustment process between the cash and futures markets will be discussed in length subsequently, but first it is useful to theoretically establish what level the basis should be and then identify a meaningful measure of basis performance.

Returning to the purely competitive model of basis determination set forth in Chapter II, it is shown how competitive forces generate a price structure that is consistent with costs. From a broad perspective, this outcome, where the marginal cost equals the marginal benefit of transformation, represents an efficient allocation of resources in terms of Pareto criteria. The same principal can be applied to the basis between the cash price of the input and the futures price of the output. Economic theory suggests that, ideally, the basis should equal the economic cost. The economic cost includes out of pocket expenses as well as costs that are not directly observed, such as a risk premium, a convenience yield or a return to fixed investment. Given that we consider basis levels equal to cost to be consistent with economic theory, one measure of basis performance is deviation of actual basis values from the ideal level.

Analytical Framework

In this section, an equilibrium approach is taken to develop an analytical framework that will be used to examine basis performance under various sets of assumptions. While disequilibrium analysis has been used to analyze futures markets, an equilibrium approach is more useful in the present study because the focus is on the relationship between the cash and futures markets, rather than the performance of either market separately. While equilibrium may never be reached between the two markets, the equilibrium adjustment process is useful in describing the direction of adjustment. It becomes evident that hedgers are the driving force in the adjustment process. The role of speculators and expectations within the analytical framework is also considered.

First, it is necessary to assume that potential hedgers exist. Hedgers are of paramount importance in linking the cash and futures markets because they are the agents who can arbitrate. It is the potential to arbitrate that dictates the relationship between the two markets. Depending on their position in the cash market, some hedgers sell futures while others buy futures. In order to simplify the illustrations, only short hedgers are discussed, but the analysis applies equally well to long hedgers.

Given that there are potential hedgers, an equilibrium approach can be used to identify economic incentives that induce buying and selling in the cash and futures markets. Consider Figure 3.1 that depicts basis levels on the horizontal axis. The medial line is a delimiter where the basis equals economic costs. The basis is defined as the futures price (F) minus the cash price (P). To the right of center the basis exceeds cost and to the left of center the basis is less than cost.

The forces that act to equilibrate the cash and futures markets--to where the basis equals cost--are

B = C

Basis < Cost	Basis > Cost
cash market: demand for cash input falls causing P ↓	cash market: demand for cash input increases causing P ↑
futures market: supply of futures contracts falls causing F ↑	futures market: supply of futures contracts increases causing F ↓
result: F - P ↑ that is, basis widens	result: F - P ↓ that is, basis narrows
direction of adjustment: --> --> -->	direction of adjustment: <-- <-- <--

(narrow basis) B = C (wide basis)

P = cash price
F = futures price
C = transformation cost
B = basis

Figure 3.1. Basis Adjustment Process.

described in each half of the figure. On the right side where the basis exceeds cost, a producer has the incentive to buy cash inputs and simultaneously sell futures. As defined, a hedger has the potential to deliver against the futures contract. Thus, the viable hedger's return from transforming a product is at least the basis, adjusted for transaction costs, such as brokerage commissions and any transfer costs that would be incurred in the event of delivery.

On the left hand side, where the basis is less than the transformation cost, there is no incentive to place a short hedge. In addition, for a producer who does not want to initiate the transformation process unhedged, there is no incentive to buy cash inputs.

The hedgers' buying and selling actions affect prices in the cash and futures markets. On the right hand side, which represents too wide a basis, the increased demand in the cash market (Dp) causes upward pressure on prices, assuming that the input supply elasticity is less than perfectly elastic. The hedgers' selling actions (Sf) in the futures market cause downward pressure on price in the futures market, ceterus paribus. The combined affect of these actions tends to narrow the basis since the difference F - P becomes smaller as F decreases and P increases.

Accordingly, the direction of adjustment is towards the basis at a level consistent with cost. The wider the basis, the greater the potential returns from executing a hedged transformation and thus, the greater the corrective forces should be.

On the left hand side where the basis is less than cost, the reduced supply of futures contracts, brought on by the lack of a short hedging incentive, exerts upward pressure on futures prices, ceterus paribus. For those producers reluctant to initiate the transformation process unhedged, the decreased input demand causes downward pressure on price in the cash input market. The combined action causes a widening force on the basis since the difference F - P increases. Once again, the direction of adjustment is towards the basis level that equals cost.

The above discussion relies on an individual's hedging incentives or disincentives to drive the adjustment process. How strong these adjustment forces are at the aggregate level depends on what assumptions are made about producers' behavior and industry characteristics. As emphasized before, without hedgers, there is no mechanism to integrate the cash and futures markets. For this reason, the burden of equilibrium adjustment between the two markets is oriented towards the supply side where arbitrators (hedgers) react to basis levels. If the potential to arbitrate is very strong, then prices in the cash and futures markets will be highly correlated and the difference between prices should tend towards cost levels.

Factors such as supply elasticity can limit the potential to arbitrate. Therefore, these factors work through the arbitrage potential to affect basis performance. The focus of this research is to identify such factors and analyze how they affect basis performance.

In the present model of basis determination, the role of expectations is not as critical as it would be in analyzing price movements in either the cash or futures market in isolation. The results would be relatively insensitive to the choice of the behavioral assumption regarding expectations. The analytical framework set forth implies nothing about absolute price levels in either market, rather, it defines an adjustment process between the two markets. Changes in expectations affect both markets if they are linked by the potential to arbitrate. Therefore, the relationship between the two markets is not directly contingent on how expectations are formed.

Expectations enter the analysis indirectly by influencing hedging decisions. For instance, if a producer anticipates high output prices, he may choose to speculate on prices and proceed with the transformation process unhedged, even if the basis is sufficiently wide to insure an economic return to a hedged position. Alternatively, a producer may initiate a transformation process even if the basis is less than cost and speculate that the cash price of output will cover his costs when he markets his output. Such decisions may decrease the effectiveness of the adjustment mechanism and this aspect will be dealt with subsequently.

In the next section, alternative assumption sets are applied to the theoretical model. First, assumptions corresponding to pure competition are maintained in order to examine basis performance under ideal conditions. Then the assumptions are systematically relaxed and important factors affecting basis performance are identified. The outcomes of the various models are then contrasted.

Theoretical Model

In the analysis, the term producer is used to refer to anyone who has a position in the cash market, that is, has the potential to control the physical commodity. Thus, in the context of this research, producers include processors, handlers, meat packers, elevator operators and anyone who can actually make or accept delivery to fulfill a futures contract. Before examining the various models, a set of assumptions maintained throughout the analysis are as follows:

(1) Producers act rationally and would make decisions consistent with the marginal conditions of equating price and marginal cost, if price were known.

(2) Producers know costs, which are constant over the transformation period or can be procured before initiation of the transformation process.

Assumptions (1) and (2) imply that producers within an industry do respond to price signals. Suboptimal output levels arising from input price variability are not considered. Assumption (2) is not overly restrictive for storage costs, which are fairly constant. In addition, livestock feeders may have the option to forward contract their inputs, employ custom feeding or place a long hedge for the primary inputs. This assumption is less plausible for crop producers where costs are more difficult to calculate and costs vary with environmental conditions.

(3) There is perfect knowledge about current market conditions.

This assumption is not overly restrictive given contemporary communication systems where price and market information is disseminated quickly and accurately.

(4) Producers are risk averse; that is, for a constant income level, an activity with lower price variability is preferred to one with greater price variability.

Assumption (4) identifies the impetus to hedge.

(5) Hedgers can meet margin calls if they arise.

Assumption (5) protects against involuntary liquidation of a hedged position. It implies that if a producer sells a futures contract at time t that matures at t+k, then he can ride out any adverse basis movements between t and t+k, thus maintaining the option to deliver at t+k.

(6) Any spatial basis is consistent with transfer costs.

Analysis of the spatial dimension of a basis is beyond the scope of this research endeavor. It differs from the form and time transformations because the uncertainty arising from the time dimension does not directly affect spatial equilibrium. Therefore, transfer costs will be accounted for when necessary, but no attempt will be made to evaluate or analyze their levels.

Version (1)

In this first version of the model, the assumption set is defined such that the perfectly competitive outcome with respect to time and form transformations can be achieved. Specifically, the assumptions fundamental to this outcome are as follows:

(1) Producers are willing and able to use the futures market to hedge their cash position.

(2) There are no outside constraints to the competitive functioning of the markets, that is, no government programs, monopolies, market manipulations, etc.

(3) Producers have complete supply flexibility in getting into and out of the market.

Decision rule: Producers will initiate a hedge if the basis is greater than or equal to the transformation cost. They will not initiate a transformation process unless the hedge will cover costs.

Given the above assumptions and applying the analytical framework, the model results in a basis level equal to cost, providing there is sufficient speculative activity to operationalize the futures market. This outcome can be shown by returning to Figure 3.1, where the adjustment process is outlined. The basis level consistent with cost is realized in this version because, by assumption, there are no impediments to the potential to arbitrate and producers do not initiate transformations unhedged. Thus, under the heroic assumptions of a perfect market the following holds:

(3.1) $B_t = F_t^{t+k} - P_t = C_t^{t+k}$ where $k >= T$

For a form transformation:

B_t = input/output basis

F_t^{t+k} = current price of futures contract (output) specified for delivery in t+k

P_t = cash price of input

C_t^{t+k} = total variable costs associated with transforming over period t to t+k

T = time required to transform input to output

For a time transformation:

C_t^{t+k} = total carrying costs from t to t+k

$T = 0$

no physical change over t to t+k

Version (2)

In this second version of the model, the third assumption regarding supply flexibility is relaxed and the decision rule is modified to be more realistic.

(1) Producers are willing and able to use the futures market to hedge their cash position.

(2) There are no outside constraints to the competitive functioning of the markets.

Decision rule: Producers are willing to place a hedge during the course of the transformation process if the potential for a profitable hedge arises. They will initiate a transformation unhedged if basis conditions are not favorable at that time.

The decision rule above implies asymmetry in the basis adjustment process. For short hedging, the adjustment described on the left hand side of Figure 3.1 is not as strong since, by assumption, producers will initiate unhedged transformations. Therefore, the demand in the cash market is not suppressed and P does not fall. Under the new decision rule, the analytical framework is shown in Figure 3.2. The basis levels on

Basis < Cost	B = C	Basis > Cost
		cash market: demand for cash input increases causing P ↑
futures market: supply of futures contracts falls causing F ↑		futures market: supply of futures contracts increases causing F ↓
result: basis does not necessarily widen, inverted basis may persist		result: F - P ↓ that is, basis narrows
		direction of adjustment: <-- <-- <--
(narrow basis)	B = C	(wide basis)

P = cash price
F = futures price
C = transformation cost
B = basis

Figure 3.2. Asymmetrical Basis Adjustment Process.

the left hand side are known as inverted since the basis is less than cost.

There are two primary reasons why an inverted basis may persist. The most pronounced reason is the inability to bring future production into the present time period. In this respect, temporal allocation differs fundamentally from spatial allocation because of asymmetry inherent in the time dimension. For instance, with a seasonally produced storable commodity such as corn, there is no theoretical limit to the magnitude of the inverted basis. When current quantities are valued higher than future supplies, then the inverted basis signals inventory depletion and abatement of storing into future periods. In such situations the cash price reflects current relative shortages while the futures price reflects anticipation of future supplies.

A second reason why an inverted basis can persist in this model is because in many agricultural enterprises there are few production alternatives, as a result of climatic conditions or specialized capital inputs. In the case of an inverted basis, many producers would rather initiate the transformation and speculate on prices than let their fixed investment lay idle. As long as their price expectations are greater than variable cost, producers are likely to operate.

Given the assumption set in Version (2), it is possible to examine the impact of marketing and supply inflexibilities on the basis adjustment process. The potential to arbitrate insures basis levels that are consistent with cost. Factors that decrease this potential affect the arbitrage potential and therefore, basis performance. Factors such as perishability, production seasonality, fixed investment and time requirements can affect a producer's marketing or supply flexibility. Therefore, these characteristics are expected to affect basis performance.

The tree diagram in Figure 3.3 allows classification of commodities by various factors affecting flexibility. Each branch divides into two segments that represent opposite extremes of being flexible or inflexible. In actuality, commodities lie somewhere between extremes but double branching serves to illustrate the concept without complicating the diagram unnecessarily.

All commodities can be located on the bottom lines in the diagram. For instance, the production of fresh fruit represents a form transformation, requiring time, that is produced seasonally and is nonstorable. Alternatively, storing wheat represents a time that can be carried across seasons. The position of commodities within the diagram indicates the degree of marketing and supply flexibility. Hence, the position

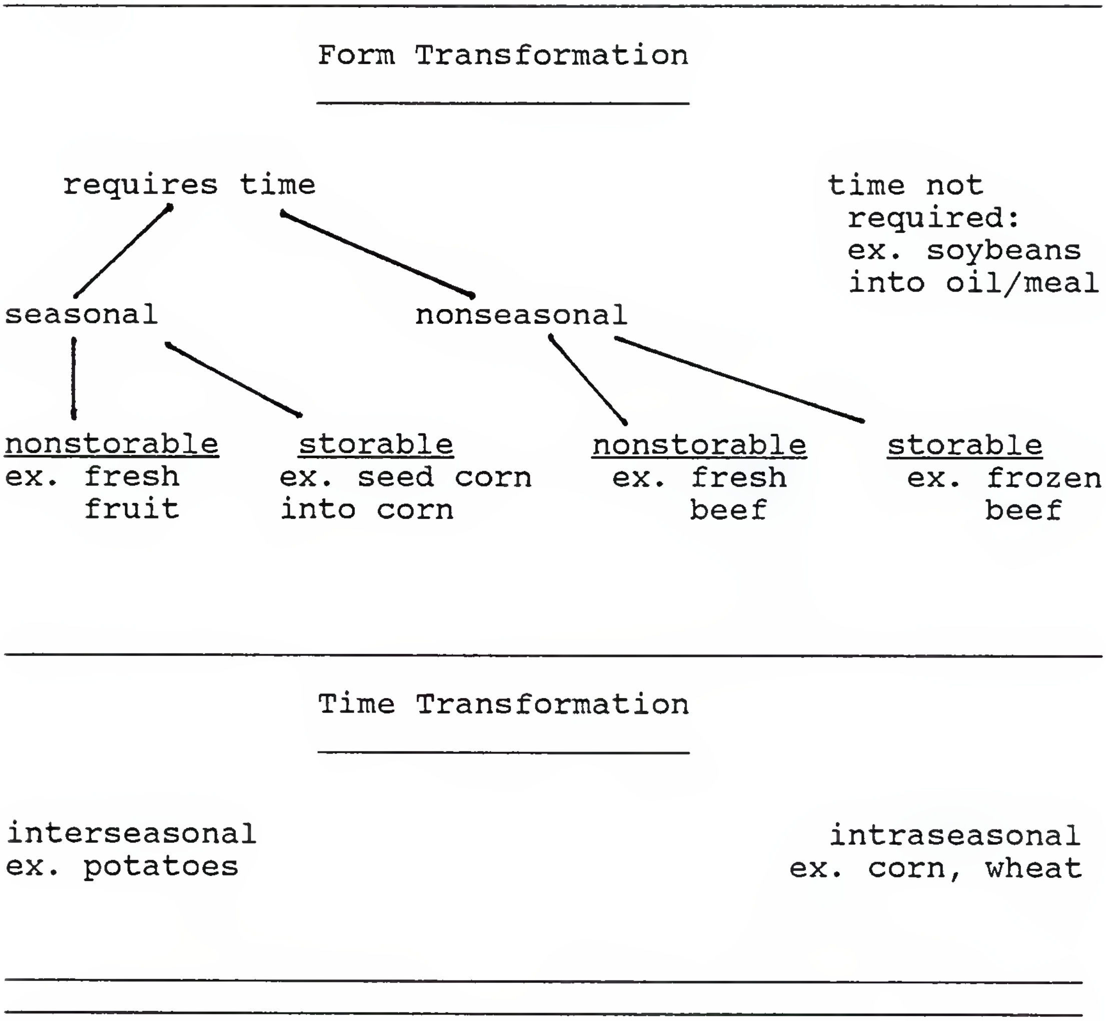
Form Transformation
requires time
time not required: ex. soybeans into oil/meal
seasonal
nonseasonal
nonstorable ex. fresh fruit
storable ex. seed corn into corn
nonstorable ex. fresh beef
storable ex. frozen beef
Time Transformation
interseasonal ex. potatoes
intraseasonal ex. corn, wheat

Figure 3.3. Commodity Classification by Type of Transformation.

also indicates whether or not a commodity transformation will be suited for the futures market.

The model above can be expressed in a generalized mathematical form.

(3.2) $BD = f(A\ [\epsilon(PI,S,FC,T)]\ )$

BD = basis deviation
BD = $|\ B - C\ |$; BD measures the difference between the basis and the economic cost
A = potential to arbitrate
ϵ = industry supply responsiveness
PI = perishability
S = seasonality of production
FC = level of fixed cost in relation to variable cost
T = time requirement for form transformation

Equation (3.2) shows how industry characteristics work through the arbitrage potential to affect basis performance. The industry supply responsiveness (ϵ) can be influenced by several factors. Both perishability and seasonality affect supply responsiveness. In addition, the ability to store and the ability to produce frequently are partial substitutes if continuous consumption is desired. The proportion of fixed cost to variable cost, as measured by FC, indicates the degree of input fixity in an industry. As before, T stands for the time required to complete a form transformation.

Totally differentiating (3.2) yields

(3.3) $$dBD = (\partial f/\partial A)\partial A/\partial\epsilon\ [\partial\epsilon/\partial PI\ dPI + \partial\epsilon/\partial S\ dS + \partial\epsilon/\partial FC\ dFC + \partial\epsilon/\partial T\ dT].$$

The expected signs of the partial derivatives are as follows:

$\partial A/\partial \epsilon > 0$
As an industry's supply response increases, the potential to arbitrate increases since the options to deliver against hedges increases.

$\partial \epsilon/\partial PI > 0$
The ability to store adds marketing flexibility. A highly perishable commodity must be marketed immediately whereas holders of storable products have greater flexibility in timing their marketing.

$\partial \epsilon/\partial S < 0$
As defined, supply responsiveness decreases as S increases. The more often a commodity can be produced within a season, the greater the marketing flexibility is.

$\partial \epsilon/\partial FC < 0$
As the fixed investment component of total cost increases, supply responsiveness falls because of the high cost involved in switching to a different production activity.

$\partial \epsilon/\partial T < 0$
When time is necessary for a form transformation, an individual's ability to arbitrate is mitigated. Whether or not this affect is manifested at the aggregate level depends on regional production patterns and what level of aggregation is considered.

The primary implication of this model is that basis performance is positively related to supply responsiveness. For example, the attribute of storability strengthens the link between the cash and futures market, so much so that cash and futures prices among different time periods have been described as a constellation (Tomek and Robinson, 1972). For nonstorable commodities such as iced broilers, frequent production periods allow producers to respond to price signals within the season, thereby potentially increasing basis performance compared to strictly seasonally produced commodities. Furthermore, from this model one would expect capacity constraints to affect basis levels for commodities characterized by high fixed costs.

In addition, for an industry where short hedging dominates, this model implies that the basis is more likely to adjust towards the cost level if it is too wide than if it is too narrow. This result arises from the decision rule that allows producers to initiate unhedged transformations. This decision rule also implies that some price risk, but not all, is shifted to speculators.

Version (3)

In this version of the model assumption (1), regarding producers' willingness to hedge, is relaxed and the assumptions and decision rule are as follows:

(2) There are no outside constraints to the competitive functioning of the market.

(3) Producers have complete supply flexibility in getting into and out of the market.

Decision rule: Producers will initiate the transformation process for the quantity where expected price equals marginal cost, when the expected price is greater than average cost.

Given that assumption (1) is relaxed so that producers or other agents are not willing to use the futures market, the analytical framework in Figure 3.1 breaks down. This occurs because without potential arbitrators, there is nothing to integrate the cash and futures markets. This version of the model emphasizes the importance of the first assumption, that producers are willing to use the market. Hedgers rely on basis performance while, simultaneously, the basis performance depends on hedgers.

Version (4)

In this version, assumption (1) is modified, while assumptions (2) and (3) remain intact.

(1)' Some producers are willing to use the market but they are not adverse to speculating on prices.

(2) There are no outside constraints to the competitive functioning of the market.

(3) Producers have complete supply flexibility in getting into and out of the market.

Decision rule: The decision to hedge is based on; (a) attitude about using the futures market, (b) personal expectations about price, and (c) yield uncertainty.

The rationale behind assumption (1)' and the decision rule is that in reality, only a small percentage of the producers in most agricultural industries hedge. For instance, in the cattle industry, only 2 percent of all production is hedged. There are several reasons that may explain the reluctance to use the futures market. One primary reason is basis risk. Also very important is the producers attitude towards the futures market. Whether it is a result of ethical reasons, bias against brokers and speculators, or ignorance, many producers do not believe in using the market. For instance, they may feel that speculators are taking advantage of hard working farmers or think that brokers' fees are too high.

Another factor that influences the decision to hedge is the individual's expectations about prices. Hedging acts to moderate gains, as well as losses. Therefore, if a person has high price expectations, he may prefer to operate unhedged and speculate on a high return. In addition, yield uncertainty can affect the hedging decision because if actual production falls short of the quantity hedged, then a producer's risk is increased.

This model can be expressed in the generalized form

(3.4) $BD = f\{ A(n[i,D(Z,X,U)])\}$.

A = arbitrage potential
n = industry supply elasticity of short futures commitments
i = percent of industry already hedged
D = decision to hedge
Z = attitude towards using the market
X = price expectations
U = yield uncertainty

Totally differentiating (3.4) yields (3.5):

(3.5) $$dBD = (\partial f/\partial A)\partial A/\partial n\ \{(\partial n/\partial i\ di\ ) + (\partial n/\partial D[\partial D/\partial Z\ dZ + \partial D/\partial X\ dX + \partial D/\partial U\ dU\}$$

The expected signs are as follows:

$\partial A/\partial n > 0$

Only hedgers have the potential to arbitrate. As the industry's supply elasticity of short contracts increases, the potential to arbitrate increases.

$\partial n/\partial i < 0$
As the percent of the industry already hedged increases, the availability of new potential short hedges declines.

$\partial n/\partial D > 0$
As the likelihood that producers will decide to place a hedge increases, the industry's supply of short futures commitments becomes more elastic.

$\partial D/\partial Z > 0$
As a producer's attitude towards hedging becomes more favorable, the likelihood that he will decide to hedge increases.

$\partial D/\partial X < 0$
As price expectations increase, the desire to hedge decreases.

$\partial D/\partial U < 0$
As production uncertainty increases, the desire to hedge falls. This occurs because if the quantity hedged exceeds actual production, then the excess amount becomes speculation in the futures markets.

Equation (3.4) shows that the potential to arbitrate depends on the supply elasticity of short contracts, n. That is, n reflects an industry's potential to come up with short run marketable supplies that could be delivered against short futures contracts. This measure is important in analyzing basis performance because it reflects the potential of the adjustment mechanism. The industry's hedging elasticity arises from hedging decisions made at the producer level. The decision to hedge is in turn governed by preferences, expectations and yield uncertainty.

The implication of this model version is that hedging decisions at the producer level aggregate to ultimately affect basis performance. Factors such as attitude and expectations affect these marketing decisions.

Version (5)

In this version of the model, the assumptions pertaining to Versions (2) and (4) are combined so that the affect of supply inflexibilities and hedging activity can be examined together. In addition, the second assumption concerning the competitive functioning of the market is partially relaxed. The assumptions and decision rule are as follows.

(1) Some producers are willing to use the market but they are not adverse to speculating on prices.

(2) There are no outside constraints to the competitive functioning of the markets except within the technical aspects of the futures market.

Decision rule: Producers are willing to place a hedge if the potential for a profitable hedge arises. They will initiate the transformation process unhedged if basis conditions are not favorable at that time.

This model can be represented in the generalized form as follows:

(3.6) $BD = f(A\ [MI,\ U,\ n\{i, D(Z,X,U)\},\ \epsilon\{PI,S,FC,T\}]\ )$

BD = basis deviation
A = arbitrage potential
MI = market index
U = production uncertainty
n = industry supply elasticity of short futures commitments
i = percent of industry already hedged
D = decision to hedge
Z = attitude towards using the futures market
X = price expectations
ϵ = industry supply responsiveness
PI = perishability

S = seasonality of production
FC = level of fixed cost in relation to variable cost
T = time requirement for a form transformation

As discussed previously, the industry's supply elasticity of short contracts (n) and the industry's supply responsiveness (ϵ) affect the potential to arbitrate and thus, basis performance. Production uncertainty (U) represents yield uncertainty inherent in the production process. For example, the yield variability associated with growing corn is greater than with feeding cattle. Production uncertainty enters the equation in two places because if affects the arbitrage potential both directly and indirectly. In one respect, it affects the producer's willingness to hedge, $\partial D/\partial U$. Secondly, yield uncertainty may affect a producer's ability to deliver against short hedges. For instance, if the quantity hedger is greater than actual production, then delivery of the excess amount is impossible. Therefore, the sign of dA/dU is negative. That is, as production uncertainty increases, the potential to arbitrate decreases.

The market index (MI) represents the technical performance of the futures market. This variable is affected by factors such as market liquidity and the accuracy and timeliness of market information. In addition, trader composition, or the relative share of hedgers and speculators within the market, has been shown to affect contract performance (Ward, 1974). As discussed in Chapter II, contract specification also affects contract performance. As a futures market contract becomes more technically efficient, it facilitates trading and arbitrage potential is increased, that is, $\partial A/\partial MI$ is greater than zero. The signs of the other partial derivatives in the total differentiation of Equation 3.6 are as presented in Versions (2) and (4).

Generalized Conclusions

The model versions discussed in this chapter imply different outcomes with respect to basis performance. The analytical framework, that specifies the adjustment between the cash and futures markets, is applied to various assumption sets ranging from perfectly competitive conditions to less restrictive assumptions. As these underlying assumptions are relaxed, the adjustment mechanism, or arbitrage potential, is altered. Consequently, basis performance differs among the alternative versions.

The assumptions underlying the model pertain either to industry characteristics or behavioral assumptions about producers. In order to ascertain the impact that industry characteristics have on basis performance, it is useful to categorize commodities according to the type of transformation as well as the characteristics that affect the potential to arbitrate. This classification indicates what factors influence the degree of flexibility in the adjustment mechanism and hence, basis performance.

The decision rule stated in each model version represents a behavioral assumption about producers with respect to their attitude towards price risk. For instance, the decision rule stipulates whether producers initiate transformations hedged or unhedged. In the theoretical model, the alternative decision rules have different implications for allocation and the burden of price risk. In terms of allocative consequences, if producers will not initiate unhedged transformations, then production decisions are based on futures market prices. For this theoretical extreme, speculators formulate the allocative signals of when and what to produce. In this case, the futures market must be evaluated in terms of its price forecasting ability; that is, does it represent an efficient method for obtaining and assimilating market information.

With regards to the futures market in its risk shifting capacity, the producer's decision rule is of primary importance in determining where the price risk falls. For producers who can deliver against a futures contract, they can completely shift price risk to speculators by hedging and thereby use the futures market as a forward contracting mechanism. For those producers who can not deliver, their ability to use the futures market as a forward pricing mechanism is mitigated. However, if the arbitrage potential is high such that basis risk is low, then those unable to deliver can use the futures market as a convenient forward pricing mechanism. The usefulness of this research is to identify factors that influence basis variability so that we have theoretical grounds for expecting how the basis for a particular commodity will perform. The empirical analysis, as set forth in the following chapter, is used to verify what commodity characteristics are significant in influencing basis performance.

CHAPTER IV
EMPIRICAL METHODOLOGY

In this chapter an empirical model of basis determination is developed. Measures of basis performance used in the analysis are discussed and exogenous variables are defined. Data, estimation procedures and treatment of technical problems are described at length. Implications of modeling assumptions are considered and testable hypotheses are set forth.

Garbade and Silber (1983) find empirical support for their contention that for storable commodities the degree of integration between the cash and futures markets depends on the elasticity of arbitrage. The general hypothesis of the present analysis is that the integration between the cash and futures markets is a function of arbitrage potential for all types of commodities, from storable to nonstorable. The integration between the markets indicates how well the competitive process is operating, and hence, reflects basis performance. Basis performance is influenced by an array of exogenous factors that differ across commodities.

The approach taken in this analysis involves examining cross sectional and time series data so that the relationship between commodity characteristics and basis behavior can be estimated. Regression analysis is used in order to establish an empirical linkage between basis performance and those variables expected to influence arbitrage potential.

For each model of basis performance, the interval of time until contract maturity is held constant. That is, all basis observations pertaining to a particular model correspond to futures contracts maturing in the same length of time, or as close as possible to the same length of time. By holding this time dimension constant, the integration between the cash and futures markets is revealed as a function of commodity characteristics, rather than a function of time-until-maturity. These data will be referred to as constant periods to maturity (CPM) series (see Malick and Ward, 1987). This approach parallels Castelino and Francis' (1982) method of examining basis variability at fixed distances from maturity for different commodities (see Chapter II).

The general objectives used to operationalize the basis performance model are as follows:

(1) Develop an empirical measure of basis performance.

(2) Identify observable factors that influence the potential to arbitrate.

(3) Incorporate (1) and (2) in an applied econometric model using cross sections of futures markets with data recorded over time.

Dependent Variable: A Measure of Basis Performance

The properties that the dependent variable must have are that first, it represents a theoretically consistent measure of basis performance; and secondly, it can be normalized for cross sectional analysis. As stated in the theoretical chapter, under ideal competitive conditions the basis should reflect the cost of transformation that it represents. Therefore, how the basis differs from the transformation cost indicates how well the competitive process operates in appropriately linking the cash and futures markets.

Figure 4.1a depicts a distribution of basis observations in relation to the reference line where the basis is equal to the cost of transformation. The distribution of the basis observations is the point of interest since this distribution reflects competitive adjustment or economic performance. For instance, using economic criteria, the distribution shown in Figure 4.1a would be judged superior to the wider distribution of Figure 4.1b. Conceptually, the distribution in Figure 4.1a represents strong integration between the cash and

Basis = Cost

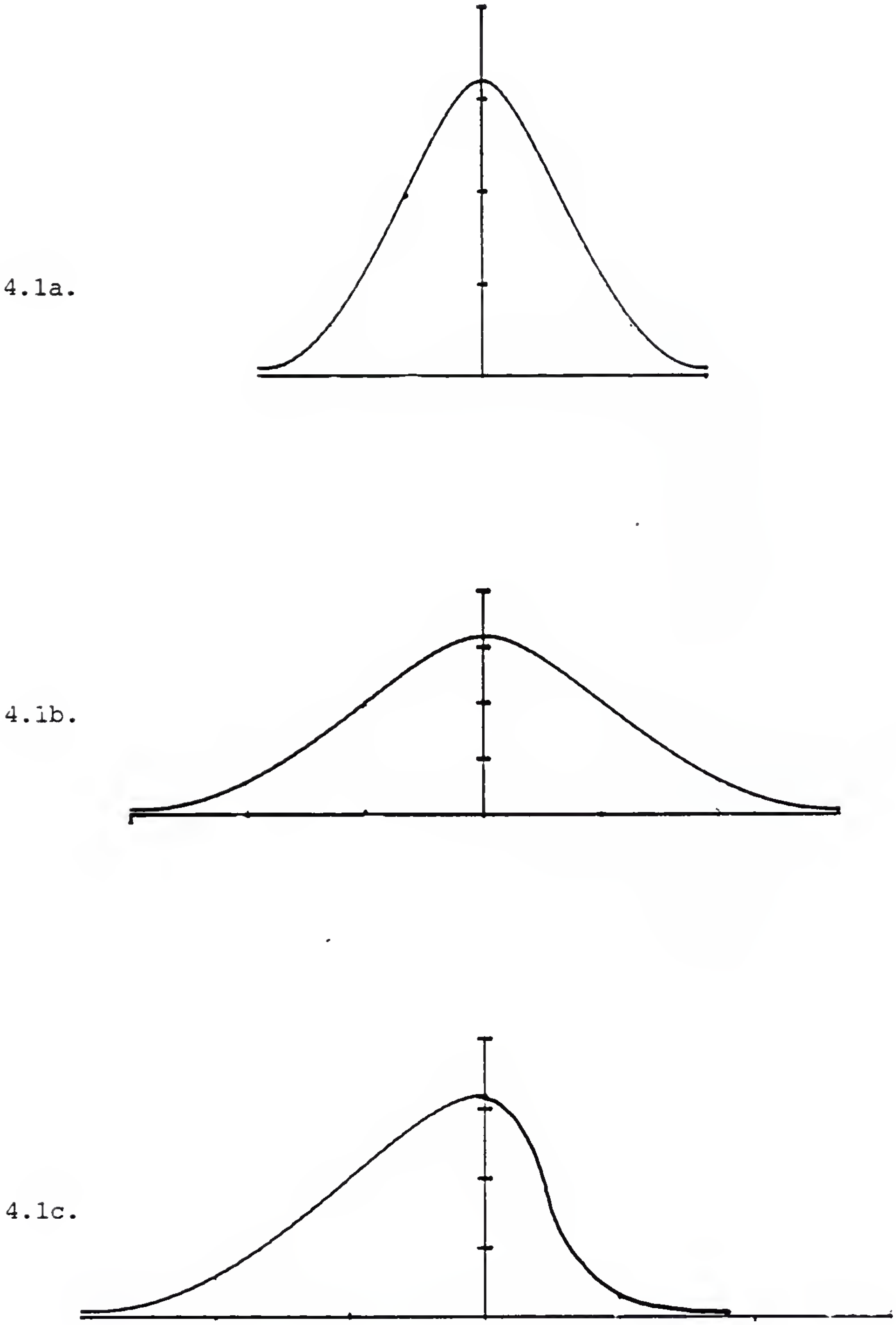

Figure 4.1. Alternative Basis Distributions.

futures markets where arbitrage activities keep the basis consistent with transformation and/or storage costs.

The distributional properties of the basis directly affect the potential returns to hedging. The variance of the basis describes the basis risk that a hedger faces, assuming appropriately defined contract specifications. Thus, the basis risk (or the variance of expected returns) associated with Figure 4.1a is less than that of Figure 4.1b. Several studies cited in this research consider the effect of basis variability on returns to hedging (Carter and Loyns, 1985; Ward and Schimkat, 1979).

Another example of how the distributional qualities of the basis affect expected returns can be illustrated with Figure 4.1c. In both Figures 4.1a and 4.1b, basis observations are distributed symmetrically around the cost level. Alternatively, Figure 4.1c depicts a skewed distribution that implies that the market adjusts differently to a basis that is greater than cost compared to a basis that is less than cost.[1] The returns to a hedged position are determined by the difference between the beginning and ending basis.[1] A widening basis is profitable to a long hedger while a narrowing basis is profitable to a short hedger. In Figure 4.1c, the likelihood of a narrowing basis is greater than the likelihood of a widening basis. Thus, for a given beginning basis value, the distribution in Figure 4.1c would favor a short hedger.

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[1] For theoretical reasons why this may be the case see Version (2) in Chapter III.

Arbitrage, in the form of hedging, integrates the cash and futures markets. Since this integration is reflected in the distribution of basis values, factors that affect the arbitrage potential affect the distributional properties of the basis. How the markets are functioning, the time from contract maturity, the institutional setting and commodity characteristics are all factors that can affect the potential to arbitrate. Therefore, theory suggests that the distributional properties of the basis will differ according to differences in these factors. Explicit identification of the relevant factors and hypotheses concerning their effect on basis distributions are set forth subsequently.

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[1] Variability between these periods, while not affecting the final outcome from trading, can create considerable uncertainty and anxiety sometimes forcing traders to deviate from normal trading plans. The present analysis does not explicitly deal with this dimension of hedging.

Other studies have focused on identifying factors that influence basis variability. For instance, Garcia, Leuthold and Sarhan (1984) found that the Consumer Price Index had a significant effect on the random fluctuation of daily basis values for Midwestern livestock.[1] Castelino and Francis (1982) identified storability, volume of existing supplies and extent of commodity substitutability as factors that were important in linking the spot and futures prices for four agricultural commodities. The empirical component of the present research includes nine agricultural commodities and a variety of factors that potentially affect basis performance.

General Model Specification

The basis residual (BR) can be defined as the difference between the basis and the cost of transformation.

$$BR = B - C \tag{4.1}$$

C = cost of transformation
B = basis = F - P
F = futures price across contracts having common intervals until maturity (CPM)
P = cash price

The standard deviation of BR [SD(BR)] provides a descriptive measure of distribution that is meaningful in the present analysis. Since the standard deviation is not independent of scale, the SD(BR) is corrected for scale differences in order to analyze variability across commodities. That is, the SD(BR) for corn (in dollars per bushel of corn) is not comparable to the SD(BR) for soybeans (in dollars per bushel of soybeans) or to SD(BR) for cattle (in dollars per hundred weight).

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[1] In their analysis, the basis was defined as the futures price of cattle minus the cash price of cattle. The basis values in the present models are defined as the futures price of cattle minus the cash price of feeder cattle.

The SD(BR) is divided by the standard deviation of the corresponding cash price so that the dependent variable reflects the variability in the basis relative to the variability in the cash price. That is, in the absence of hedging, a producer is exposed to the risk of cash price variability, whereas a hedged producer is exposed to the risk of basis variability. Therefore, the pertinent measure of basis variability should be computed so that it is relative to the cash price variability.

The integration between the cash and futures markets should respond to changes in economic conditions that affect arbitrage potential, such as rising or falling stock levels. Accordingly, basis residuals are expected to vary with economic conditions thereby reflecting changing market conditions. In general, lower values of the normalized SD(BR) are associated with better market performance than higher values of the normalized SD(BR).

The normalized SD(BR) could be calculated for each commodity and this method would yield one observation of the dependent variable per commodity, in each constant period from maturity (CPM) model. However, the model specification can be improved by further grouping the data by year and quarter. Thus, for each commodity, the weekly data within a particular year of a particular quarter are used to create $SD(BR)_{ijk}$ where i denotes the i^{th} commodity, j denotes the j^{th} year and k denotes the k^{th} quarter. Technically, this partitioning is desirable because it increases the number of observations in each regression model and helps to control for the changes in the price and cost levels that occur over time.

There is also empirical evidence that basis variability follows a seasonal pattern. Malick and Ward (1987) examine the interaction of seasonality and stock levels in the frozen concentrated orange juice (FCOJ) basis. They estimate separate basis models each representing a constant period from maturity. The monthly dummy variables are found to be significant in influencing the basis residual, which is the basis net of storage costs. Using the empirical results, they illustrate the effect of seasonality alone on the basis residual, by holding stock levels constant at a normal level. They conclude that the FCOJ market is not fully correcting and attribute the persistance of seasonality in the basis to the market structure prevailing in the FCOJ industry.

Seasonality in the basis initially implies inefficiencies within the pricing system. However, seasonality often arises among agricultural commodities because of seasonality in production, and hence, seasonality in the flow of market information. For instance, production forecasts and crop outlook reports are seasonal. Futures markets should reflect anticipations of the forecast where these anticipations are based on limited information about market conditions. Anderson (1985) empirically measures the volatility of futures prices for eight agricultural commodities. He concludes that "the principal predictable factor in changes of variance is seasonality" (p.345). He shows that the variance of futures prices is highest when the greatest degree of uncertainty (about supply and demand conditions) is being resolved.

As discussed above, there is empirical evidence that the FCOJ basis exhibits seasonality (Malick and Ward, 1987). Since Anderson found strong seasonal effects in futures price variability for a variety of commodities (including livestock), it is reasonable to expect that basis values may also vary seasonally for the commodities in the present research. That is, one would expect to see greater variability in the basis during seasons of the year when more uncertainty is resolved. To account for this possibility, data are partitioned by season within each commodity and year group.

The following equations summarize the general model specification, where $m = t + n$:

$$B^m = F^m - P^t \tag{4.2}$$

$$BR^m = B^m - C^m \tag{4.3}$$

$$\begin{aligned} VAR(BR) &= VAR(B - C) \\ &= VAR(B) + VAR(C) - 2\{COV(B,C)\} \end{aligned} \tag{4.4}$$

$$VAR(B) = VAR(F) + VAR(P) - 2\{COV(F,P)\} \tag{4.5}$$

Substituting (4.5) into (4.4) and normalizing the standard deviation of the basis residual SD(BR) with the standard deviation of the cash price SD(P) yields equation (4.6).

$$SD(BR)_{ijk}/SD(P)_{ijk} = \sqrt{\{VAR(F)+VAR(P)-2[COV(F,P)+VAR(C)-2[COV(B,C)]]\}}/\sqrt{VAR(P)} \tag{4.6}$$

The $SD(BR)_{ijk}$ is calculated conditioned on commodity (i), year(j) and season(k).

In equation (4.6) the SD(BR) for a particular commodity in a particular quarter of a particular year is divided by the standard deviation of the cash price SD(BR) in the corresponding group. This denominator serves to cancel units, adjust for changing price levels and express the variability of the basis in terms relative to the variability of the cash price. This approach parallels Ward and Schmikat's (1979) method ofusing a risk ratio in their analysis of basis risk in Florida feeder cattle.

Let X and Z represent variables affecting arbitrage potential, then:

(4.7) $SD(BR)_{ijk} = f(X,Z)$.

The independent variables in the model above are represented in two categories; X and Z. Exogenous variables in the first category (X) correspond to factors that reflect the trading process in the futures market, such as the market liquidity and the hedging to speculative ratio, as well as variables that relate to each commodity's physical or marketing characteristics. For instance, indexes for storability and exports relative to domestic production are included in type X variables. The second category, Z, is comprised of the seasonal dummy variables by which the data are partitioned.

Data and Model Implementation

Selected Commodities

The commodities included in the present study are listed in Table 4.1. This data set is more extensive than those used in previous studies and includes nine agricultural commodities recorded over approximately a fifteen year period. The general objective was to construct a data set with commodities that possessed a

Table 4.1. Agricultural Commodities Included in the Empirical Model of Basis Perfomance.

Type of transformation	Commodity in futures mkt.	Commodity in cash mkt.	time series
time	Corn	Corn	1970-1984
time	Wheat	Wheat	1970-1984
time	Oats	Oats	1976-1984
time	Soybeans	Soybeans	1972-1984
time	FCOJ	FCOJ	1973-1984
time	Frozen pork bellies	Frozen pork bellies	1970-1984
form & time	Soybean oil	Soybeans	1970-1984
form & time	Soybean meal	Soybeans	1970-1984
form	Live cattle	Feeder cattle	1972-1984

wide variety of production and market characteristics. Commodities such as cotton, sugar and coffee were excluded from the analysis because of the extensive market intervention associated with these commodities.

The first four commodities listed in Table 4.1 exemplify the grain group conventionally used in the analysis of basis determination for storable commodities. While the production patterns and degree of storablility are very similar among these commodities, they differ in other characteristics expected to affect the potential to arbitrate. For example, exports in relation to domestic production is much higher for corn than for oats. Thus, even within the grain group there is variability in the exogenous factors.

Frozen concentrated orange juice is another storable commodity that was selected because its production and industry characteristics differ considerably from the grain group. In addition, including FCOJ in the present analysis allows comparison with the results of Malick and Ward (1987). Frozen pork bellies were included in the data set because they differ from the grain group in two fundamental ways. First, the pork production process is much less seasonal than grain. Secondly, frozen pork bellies have an intermediate degree of storability since their quality declines after six to eight months of storage.

In the present analysis, the conversion of soybeans into soybean oil and meal represents a combination of form and time transformations. To model the form dimension, basis values were created by subtracting the cash prices of soybeans from the futures prices of oil and meal, adjusted for soybean equivalence. The conversion of feeder cattle into fed cattle represents a form transformation that is distinct from the soybean oil and meal conversion in that fresh beef can not be stored. For this reason, the live cattle contract is especially important in the analysis.

Components of the Dependent Variable

Computation of the dependent variable, SD(BR), requires cross commodity data on futures prices, cash prices and cost levels. Appendix A lists the futures contracts and specifications along with a description of the associated cash markets. It is apparent that the specifications in the cash and futures markets do not align precisely in terms of delivery point and/or grade. An underlying premise in the present analysis is that any relative price differences attributable to grade or location differences have been constant over the time series. If the assumption does not hold, then variation in location or grade differentials will contribute to the general level of basis variability. This additional variation would be unexplained in the empirical models and reflected in the residuals.

The basis. Cash and futures prices used in the analysis represent weekly averages. Weekly time aggregation was selected because it acts to filter the random effect of daily trading noise that would be unexplainable in the present analysis. Furthermore, a weekly average represents a short enough time interval to capture hedging decisions made in the market. In calculating weekly averages, daily futures prices were weighted by trading volume thereby assuming that prices associated with heavy trading are more indicative of market conditions than prices resulting from light trading.

Basis values were defined in such a manner that they would reflect a constant time interval from maturity. This time dimension is held constant so that basis performance is revealed as a function of commodity characteristics rather than time-until-maturity. Three separate models with basis values corresponding to six, four and two months until maturity were specified. This range is meaningful since it offers relatively long and short time periods, but avoids interseasonal and delivery month trading--both of which would be inappropriate in the present analysis.

Let F^m represent a $1 \times \Sigma t_i$ vector of futures prices where t refers to the number of weekly averaged observations, i refers to the commodity and m stands for the months until contract maturity. Since m is held constant in each regression model, this superscript is deleted for simplicity. Correspondingly, P is a $1 \times \Sigma t_i$ vector of cash prices. For example, in the case of cattle, P represents the cash price of feeder cattle expressed in appropriate units. The basis vector (B) is calculated as F - P and B represents basis values (across different commodities) corresponding to a given time until contract maturity.

Partitioning scheme. In each model data were grouped by commodity (i), year (j), and season (k). The season grouping was specified by quarters to coincide with quarterly stock level reports, as well as the production seasonality in agricultural commodities.

Costs. A vector of costs (C) corresponding to the various time and form transformations was used to create the basis residual vector (BR). It was not feasible in the present analysis to determine weekly cost estimates to correspond directly with the basis observations. However, the cost figures used in the analysis were adjusted for the appropriate time intervals in the regression models. For instance, if the time between t and t+n in the basis observation B_t^{t+n} is four months and two weeks, then the storage cost observation subtracted from B is adjusted to reflect the cost of carrying the commodity for that particular time interval.

For corn, wheat, oats and soybeans, annual storage rates paid by the Commodity Credit Corporation were used to approximate storage costs. The annual storage cost figures for frozen concentrated orange juice were obtained from Cost of Processing, Warehousing and Selling Florida Citrus Products. Because time series data on storage costs for frozen pork bellies were not available, an index was used to deflate a 1985 observation on the monthly storage charge for frozen pork bellies. The FCOJ cost series was used to create this index because factors such as energy costs, which greatly influence the cost of frozen storage, would also be expected to have a parallel impact on the cost of frozen storage for pork bellies.

In the form transformation of feeding cattle, cost figures are based on Corn Belt Cattle Feeding budgets as presented in the series Livestock and Meat Situation. These budgets show selected expenses--such as corn, silage, transportation, labor, interest and equipment--incurred in the process of feeding a 600 lb feeder steer to a market weight of 1100 lb.[1] Production schedules in the budgets begin each month, therefore, expenses such as corn change monthly with changes in factor prices.

In the present analysis, the feeder steer's weight and finishing cost are defined the same in the two month model as in the six month model, even though such a conversion is physically impossible in a two month time period. Thus, cost figures are invariant to time differences reflected in the basis. This specification is consistent with the theoretical framework set forth in Chapter III, in which the cattle conversion would be classified strictly as a form transformation. For time intervals less than what is required to complete the transformation, such as two months in the present example, the potential to arbitrate is mitigated. The empirical model is specified so that higher levels of basis variability resulting from the lack of arbitrage potential will be explained.

Unfortunately, processing cost data were not available for the transformation of soybeans into soybean oil and meal. One alternative was to use observed spot price spreads between the value of products (oil and meal) and soybean prices as prepared in the series Oil Crops Outlook and Situation Yearbook.

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[1] The cost of the feeder steer in the budget was subtracted from the total expenses since the cash prices of feeder steer were already used in computing the basis.

Using this approach would require relying on the maintained hypothesis that the local Decatur spot market was perfectly competitive and that soybean processors in that area were representative of processors elsewhere.

Because it is doubtful that the assumption above would hold for such a localized market, an alternative approach using futures price spreads was considered for estimating processing cost. This method assumes that the soybean, soybean oil, and soybean meal futures are well integrated by those trading in futures markets. This alternative, which was originally suggested by Glauber[1], is preferred to the spot market approach since the futures market represents a highly liquid national market.

As discussed in Chapter II, the soybean processing industry is characterized by high fixed costs relative to variable costs. Crush margins follow seasonal patterns that coincide with crush demand and thus, these margins reflect changes in the processors' opportunity cost. For instance, Table 4.2 shows the crush margin for the Decatur spot market in 1983 was $.47 in October and $.15 in March. Notice also from comparing 1982 and 1983 that the seasonal pattern is not the same across

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[1] Joseph Glauber is a researcher in the crops branch of NED/ERS/USDA.

Table 4.2. Monthly Soybean Crush Margins for the Decatur Spot Market, 1981-1983.

Date	Spread between value of products and soybean price
1981/82	
September	.35
October	.15
November	.04
December	.22
January	.19
Febuary	.26
March	.25
April	.22
May	.24
June	.16
July	.21
August	.24
1982/83	
September	.33
October	.47
November	.30
December	.31
January	.21
Febuary	.22
March	.15
April	.18
May	.30
June	.27
July	.25
August	.39

Source: Oil Crops Situation and Outlook Yearbook. Economic Research Service, U.S.D.A. Washington, D.C. July (1986).

years, as the factors influencing crush demand are likely to differ among years.

Likewise, futures price spreads exhibit strong seasonality. The spread method of estimating processing costs was rejected in this analysis because basis values are defined for time intervals in which crush margins (estimated with spread values) varied substantially. For instance, in the six month model a basis interval could be from July to January, a time interval in which the crush margin would vary considerably. Furthermore, and perhaps a more obvious problem with the futures spread approach is the endogeneity of using futures prices both to compute the basis as well estimate a cost measure that is intended to be independent of the product market.

Ultimately, a more simplistic method of estimating processing costs using annual crush margin data for 1970 through 1984 was selected. As shown in Table 4.3 even yearly data are quite variable. Notice how the crush margin increased significantly in 1972. The corresponding soybean price went from $3.24 in 1971 to $6.21 in 1972. This pattern suggests that the crush margin varies with price level rather than responding unilaterally to changes on the cost side.

In order to account for changes in cost but desensitize the cost measure to changing price levels,

Table 4.3. Yearly Soybean Crush Margins for the Decatur Spot Market, 1967-1983.

Year	Spread between value of products and soybean price
1967	.12
1968	.12
1969	.48
1970	.26
1971	.09
1972	.60
1973	.72
1974	.17
1975	.16
1976	.19
1977	.28
1978	.36
1979	.41
1980	.23
1981	.21
1982	.28
1983	.22

Source: Oil Crops Situation and Outlook Yearbook. Economic Research Service, U.S.D.A. Washington, D.C. various issues, 1967-1984.

the crush margin was averaged over three time intervals: 1967-1971, 1972-1976, 1977-1983. The assumption is that over a long run period the crush margin represents a per unit return for processing services that is consistent with the costs, both variable and fixed, of providing these services. The implications of using the cost estimates, as defined for the various commodities, is discussed in the following paragraph.

In the empirical methodology, a potential source of error introduced by using costs that are constant within each quarter or year can be seen in 4.8.

$$\text{(4.8)} \quad \begin{aligned} VAR(BR) &= VAR(B-C) \\ &= VAR(B) + VAR(C) - 2COV(B,C) \end{aligned}$$

Clearly, the variance of cost [VAR(C)] may be underestimated by using average cost figures in the time and form transformations. Actual economic costs fluctuate daily with changes in the interest rate and other input prices. However, two factors act to moderate the stringency of the constant cost assumption. First, it is likely that many hedgers do not reformulate estimates of their costs on a daily or weekly basis; but rather, they base their hedging decisions on costs averaged over a longer time interval. Secondly, underestimating the fluctuations in the interest rate has a similar impact across all commodities in the regression models.

Independent Variables

The first two variables included in the regression analysis pertain to technical performance in futures markets and correspond to the "market index" in the theoretical model. Market liquidity influences the potential to arbitrate because in an illiquid market, a trader must incur higher costs in order to establish or close out a futures position. Malick and Ward (1987) found market liquidity to be a significant factor influencing the FCOJ basis residual for models corresponding to two and four months from maturity.

In the present analysis, market liquidity (ML) is defined as the volume of trading divided by open interest. Open interest reflects current established positions that must eventually be terminated, while volume simply shows the amount of contracts traded in some time period. Some trades reflect new open interest while others result from closing positions. That is, volume reflects both entry and exit activity. Liquid markets should have considerable volume to facilitate ease of entry and exit relative to market size (open interest). Hence, liquidity is expressed with the proxy variable of volume relative to open interest. Basis variability should decline with highly liquid markets since potential price distortions can be quickly corrected.

Since it is likely that volume and open interest follow a seasonal pattern related to hedging interests, this variable was partitioned by season before being averaged. Thus, ML is averaged over weekly observations according to season and year within each commodity as expressed in (4.9).

(4.9) $ML_{ijk} = VOL_{ijk}/ OI_{ijk}$

VOL = trading volume
OI = open interest

The second variable, called the hedging ratio (HR), is used to represent the ratio of hedging to speculation. This variable is expected to influence basis performance because hedgers represent the potential arbitrators that serve to integrate the cash and futures markets. Data on the commitments of futures traders are available from the Commodity Futures Trading Commission, however, only traders holding large commitments in excess of 25 contracts are required to report their positions. Therefore, the ratio of reported hedging to total open interest can potentially understate the actual proportion of hedgers.

There are several studies that address the issue of allocating nonreported trading commitments (Larson, 1961; Rutledge, 1978; Ward and Behr, 1983). Ward and Behr offer an allocating scheme based on the premise that markets with high levels of nonreported commitments are heavily speculative and their results are consistent with the survey results found by Rutledge. Ward and Behr's model defined as

(4.10) $H = RH + NR(RH/TR)\{1 - [NR/(NR + TR)]\}$

RH = reported hedging
NR = nonreported hedging
TR = total reported positions

is used to estimate the numerator in 4.11.

(4.11) $HR_{ijk} = H_{ijk}/TR_{ijk}$

Because of potential seasonality in HR, data were collected for January, April, June and October to correspond with the quarterly specification. The hypothesized sign of HR is negative since a relative increase in potential arbitrators is expected to increase basis performance by reducing basis variability.

The next two variables correspond to a commodities import and export characteristics and are expected to have a potential influence on basis variability. The variables IM and EX are defined in equations (4.12) and (4.13).

(4.12) $IM = \text{imports}_{ij}./\text{total domestic consumption}_{ij}.$

(4.13) $EX = \text{exports}_{ij}./\text{total domestic production}_{ij}.$

i - commodity j - year

Yearly data on production, consumption, imports and exports were obtained from Agricultural Statistics.

There are many dimensions that must be considered when examining the effect that imports and exports have on basis variability. In essence, imports and exports act to broaden the potential market area. With a large international market there is a broader population of factors, such as exchange rates, that can potentially affect prices in the cash and futures markets as compared to a strictly domestic market. Thus, market participants are acting on a broader information set than in a domestic market. In addition, it is likely that a broader range of traders, including international traders, participate in buying and selling activities.

The variables EX and IM as defined above are likely to confound a number of different and perhaps conflicting affects that an international market environment can have on basis variability. It is hypothesized that exports (EX) as defined in (4.13) will decrease basis variability since there is a broader range of traders participating in an international market, than in a strictly domestic market. The hypothesized sign for imports (IM) as defined in (4.12) is negatives because factors that increase supply elasticity should increase the potential to arbitrate, thereby decreasing basis variability. However, since the variables EX and IM represent a composite of potential influences it is not possible to empirically test a hypothesis for a particular component of the composite.

Stock levels affect two factors, the convenience yield and risk premium, which influence basis levels (Brennan, 1958; Ward and Dasse, 1977; Malick and Ward, 1987). Since the convenience yield and risk premium are unobservable, a stock index was used as a proxy to capture the potential affect that the convenience yield and risk premium have on basis variability. In addition, the potential to arbitrate is greater when stocks are available than when stocks are relatively scarce.

Quarterly stock data were used to create the stock index (STX) that expresses current quarterly stock levels relative to the average stock level for the corresponding year, as shown in 4.14.

(4.14) $\text{STX} = \text{stock level}_{ijk}/\text{mean stock level}_{ij}$.

Quarterly stock data were used as published by the Crop Reporting Board and Grain Stocks Report. In the case of live cattle, the number of animals on feed was treated in the same way as stock levels for the other commodities. Leuthold (1977) found the number of cattle on feed to be a significant factor affecting basis levels.

At times when stock levels are high, the potential to arbitrate between the cash and futures markets is greater than when stock levels are low. Therefore, the hypothesized sign for the stock index (STX) is negative.

Theoretically it was argued that factors that affect marketing or supply flexibility influence arbitrage potential and hence, affect basis performance. The degree of storability for a commodity affects marketing flexibility since holders of storable products have greater flexibility in timing their marketing. In the empirical analysis, three degrees of perishability were identified and treated as dummy variables. The grains and FCOJ were grouped together as the most storable, P1. Frozen pork bellies were assigned a different dummy variable, P2, because this commodity is only stored for up to six months. Fresh beef represents the most highly perishable commodity in the analysis and cattle was used as the base.

Summarizing, the implicit model specification is shown in equation (4.15)

(4.15) $Y = f(\, ML, HR, EX, IM, STX, P_i)$

where P_i corresponds to perishability dummy variables. According to the way in which the variables are defined, the hypothesized signs for all the coefficients in the model are negative.

Model Specification

In the preceding sections, variables expected to influence the variability of the basis residual have been identified and the signs of the coefficients have been hypothesized. The orientation of the present research, which necessitates using data across commodities, has certain implications regarding the estimation procedure, particularly with respect to assumptions concerning the error structure in the regression models. Following, the functional form specified for the regression equations is considered and the estimation procedure is discussed.

Functional Form

Equation (4.15) shows the implicit relationship between the dependent variable Y and the set of independent variables X. The explicit form of this model is specified to include two *a priori* assumptions. First, the function is specified so that the variability in the basis residual (Y) must have some positive value irrespective of the levels of the independent variables. One would expect a certain degree of variability in the basis residual even if the exogenous variables were at levels that fully supported or promoted the potential to arbitrate between the cash and futures markets since adjustments between the markets are not instantaneous. Second, the function is specified to be intrinsically linear. This assumption is made for estimation convenience only.

Assumptions (1) and (2) have certain implications regarding what form the independent variables are specified in the model. If the initial model was specified as an exponential where

(4.16) $Y = \exp(\Sigma X_i\beta_i)$

and if $\beta_i > 0$, then the limit of X_i implies a second derivative greater than zero. Hence, the effects of X_i on Y would explode as X_i increases. This limitation may necessitate including a higher order form of X_i entering the model, such as X_i raised to some power. Depending on the form, it would be possible for X_i to have the positive effect but also include negative second derivatives. Using this alternative, the model still assures positive dependent variable values but allows for positive effects of X_i occurring at decreasing rates. For $\beta_i < 0$, the specification is not as critical because the lower limit is zero, in contrast to infinity for the case of $\beta_i > 0$. Conceptually, the exponential model can be represented as follows:

(4.17) $Y = \exp(\Sigma f_i(X_i))$

If $f_i(X_i) > 0$ then some function $f_j(X_j)$ is specified to allow the positive effect of f() to occur at a decreasing rate, that is $\partial f_j/\partial X_j < 0$. If f() < 0 then the limit is zero and $f_j(X_j)$ is not specified.

The explicit model specification including hypothesized signs is shown in equation 4.18:

$$(4.18)\quad SD(BR)/SD(P) = \exp(\,\alpha + \underset{(-)}{\beta_1 STX} + \underset{(-)}{\beta_2 ML} + \underset{(-)}{\beta_3 HR} + \underset{(-)}{\beta_4 IM} + \underset{(-)}{\beta_5 EX} + \underset{(-)}{\delta_1 P1} + \underset{(-)}{\delta_2 P2}\,)$$

SD(BR)/SD(P) = standard deviation of the basis residual normalized by the standard deviation of the cash price

STX = stock level$_{ijk}$ / mean stock level$_{ij.}$
ML = trading volume$_{ijk}$ / open interest$_{ijk}$
HR = hedged positions$_{ijk}$ / total positions$_{ijk}$
IM = imports$_{ij.}$ / total domestic consumption$_{ij.}$
EX = exports$_{ij.}$ / total domestic production$_{ij.}$
P1 = storable dummy variable
P2 = semistorable dummy variable
α = intercept corresponds to nonstorables

The functional form in (4.18) is intrinsically linear so that for estimation purposes the dependent variable is defined as the natural log of the normalized standard deviation of the basis residual (ln[SD(BR) / SD(P)]).

Estimation Procedure

The commodities included in the analysis are diverse with respect to production patterns, industry structure and marketing channels. For instance, the production, storage and marketing of frozen concentrated orange juice is significantly different from that of corn. Because it is highly unlikely that all of the exogenous variables that account for these cross sectional differences are included in the model, the residuals in the regression were not expected to have a common variance. Since production and marketing structures for a particular commodity have not changed dramatically or quickly, the residuals among years and quarters of the same commodity were expected to have a very similar variance. In addition, the exogenous variables in the model, which are based on quarterly and yearly data, are expected to help explain inter-commodity variance in the residuals pertaining to years and quarters. Thus, the maintained assumption regarding the error structure is that heteroscedasticity exists across the different commodities but not among quarters and years within a particular commodity.

While the data used in the analysis represent a time series, these data are manipulated before entering the estimation procedure and therefore, serial correlation is not expected. Essentially, the data are aggregated across time prior to being used in the model and thus no longer represent a continuous time series. The weekly basis residual observations are partitioned by commodity, year and quarter, and the standard deviation of the basis residual is then calculated for each group. This process acts to remove the serial correlation that would be expected to exist in a more frequent time interval, such as weekly or monthly observations. In addition, the exogenous variable pertaining to stock levels that is based on quarterly data can be expected to help explain season serial correlation if it remains in the variance structure.

The assumptions concerning the error structure can be summarized as follows.

(4.19a) $E(u_{ijk}) = 0$

(4.19b) $COV(u_{ijk}, u_{ist}) = 0$

(4.19c) $VAR(u_{ijk}) = \partial^2{}_i = \partial^2 a^2{}_i$

i = commodity
j,s = year
k,t = quarter
a_i = unknown multiplicative value (commodity specific)

As shown in (4.19a-c) it is assumed that the variance-covariance matrix is a diagonal matrix (4.19b) where the variance is constant over different years and quarters (j and k) of a particular commodity i but may differ across commodities (i). For computational convenience, the nature of the heteroscedasticity is assumed to be unknown multiplicative values, a_i, as shown in (4.19c).

If heteroscedasticity exists but is not corrected for then the parameter estimates, β's, are still unbiased. However, the estimated variances of the β's will be biased as well as inefficient (Maddala, 1977). Heteroscedasticity, when ignored, affects hypotheses tests about the regression parameters.

In testing for heteroscedasticity, Glejser (1969) suggests using the absolute value of the estimated residual from least squares as the dependent variable in regression equations with alternative specifications of the exogenous variables. A procedure similar to Glejser's approach is used in the present analysis to detect, as well as correct for, heteroscedasticity. First, the equation is run using ordinary least squares (OLS) and the estimated residuals are calculated. These estimated residuals are then squared and regressed on commodity dummy variables because, as discussed above, commodities are expected to be the source of differences in the residual variances.

The square roots of the coefficients in the dummy variable regression are the mean values of the estimated residuals (for each commodity) from the initial regression. A coefficient that is statistically significant indicates that the mean variance for the corresponding commodity is significantly different from the mean variance of the base or omitted commodity. That is, heterscedasticity is indicated if one or more of the coefficients in the dummy variable regression are significant.

To correct for heteroscedasticity, if the above procedure indicates that it exists, the coefficients from the dummy variable regression can be used as a mean correction for the variance among commodities. (If commodity dummy variables are included in the original estimation they completely dominate the model). These coefficients represent an estimate of the a_i's shown in equation (4.19c). A weighted least squares approach is employed by dividing the regression equation through by these estimates of the a_i's. Assuming that the error structure shown in (4.19c) is correct, then dividing the regression equation through by a_i results in a transformed equation with homoscedastistic residuals.

(4.20) $\ln Y/a_i = 1/a_i + \beta_1 X_1/a_i + . . . \beta_k X_k/a_i + V_i$

where $Y = SD(BR)/SD(P)$, $V_i = u_i/a_i$ and

(4.21) $VAR(V_i) = VAR(u_i/a_i) = \partial^2 a^2{}_i/a^2{}_i = \partial^2$

Because the weighted least square equation in (4.21) is characterized by homoscedastistic residuals, it can be used for hypothesis testing.

Summary

In this chapter the empirical model of basis performance was developed. The dependent variable, that reflects basis performance, was defined in terms of the variability of the basis residual and was normalized for cross commodity analysis. Exogenous variables expected to influence arbitrage potential were identified and their affect on basis performance was hypothesized. The model specification, with regard to the functional form and estimation procedure, was discussed in length. The following chapter includes the results and interpretation of the different steps in the econometric analysis.

CHAPTER V
ECONOMETRIC ESTIMATES OF BASIS RESIDUAL VARIANCE MODEL

In this chapter the explicit equation shown in (4.18) is estimated for the three constant period from maturity (CPM) models. In each of the CPM models the basis is calculated with futures prices that mature in the same length of time so that the time interval is held constant across observations within each model, as discussed at the beginning of Chapter IV. The performance of each of the various models is also considered. In order to give insight into the nature of the data, this chapter begins with an overview of the actual data used in the analysis.

Data Summary

The mean, standard deviation, minimum and maximum values for the exogenous variables are shown in Table 5.1. Market liquidity (ML) corresponds to the futures prices that make up the basis and therefore this variable is different for the two, four and six month models. The other exogenous data are the same across the different CPM models. Exports (EX) are based on yearly data and this variable is defined as exports

Table 5.1. Data Summary for Exogeneous Variables Entering the Basis Residual Variance Model.

Variable	Mean	Standard deviation	Minimum	Maximum
Exports	.25	.22	.00	1.02
Market Liquidity				
2 month	.29	.14	.03	.81
4 month	.20	.11	.02	.81
6 month	.16	.10	.03	1.34
Hedging Ratio	.51	.20	.03	.91
Stock Index	1.00	.45	.11	2.15

divided by total domestic production. The value for exports can exceed one if carryover stocks of a commodity are exported. Market liquidity (ML) is defined as futures trading volume divided by open interest and the hedging ratio (HR), based on quarterly data, is defined as the number of hedged positions divided by the total number of positions. The stock index (STX) is the quarterly stock level divided by the mean stock level in the corresponding year.

Table 5.2 shows the mean values of the exogenous variables by commodity. By definition, the mean value of the stock index (STX) is 1.0 for all commodities and therefore STX was not included in Table 5.2. The commodity shown as crush signifies the form transformation of crushing soybeans into soybean oil and meal. These mean values by commodity are of interest in the discussion of the results that follows.

Empirical Results

Initial Results

In the first step of the estimation procedure, the two, four and six month (constant period from maturity) models were specified in the exponential form discussed in Chapter IV. The exact specification is shown in equation (5.1).

$$SD(BR) \;/\; SD(P) = \exp(\alpha + \beta_1 EX + \beta_2 ML + \beta_3 HR + \beta_4 HR_2 + \delta_1 P1 + \delta_2 P2 + \beta_7 STX + \beta_8 STX^2) \tag{5.1}$$

Table 5.2. Mean Values of Exogeneous Variables by Commodity Entering the Basis Residual Variance Model.

Commodity	Exports	Market Liquidity			Hedge Ratio
		2 mo	4 mo	6 mo	
Corn	.26	.21	.16	.15	.73
Wheat	.61	.29	.22	.17	.57
Oats	.01	.19	.15	.13	.49
Soybeans	.39	.37	.23	.15	.52
Cattle	.004	.35	.28	.19	.37
Pork bellies	.001	.51	.35	.31	.12
FCOJ	.06	.12	.09	.08	.62
Crush	.26	.22	.14	.11	.62

The ordinary least squares (OLS) results from these initial regressions are reported in Table 5.3.

Initially, the parameter estimates for the variables stock index (STX) and hedging ratio (HR) had an unexpected positive sign. With this result the variability of the basis residual would increase at an increasing rate (explode) with increases of STX or HR. In order to make the models theoretically consistent with respect to second derivatives as shown in equation (4.20), squared terms for HR and STX (HR^2 and STX^2) were added to each model. This specification allows for the positive effects of these variables to occur at decreasing rates if the signs on the coefficients of the squared terms are negative. For instance, equation (5.2) shows the derivative of the dependent variable (Y) with respect to STX when STX^2 is included in the model.

(5.2a) $Y = \exp(\alpha + \beta_1 STX + \beta_2 STX^2 \cdot \ . \ . \ )$

(5.2b) $\partial Y/\partial STX = (\alpha_1 + 2*\beta_2 STX) * Y$

If $\beta_1 > 0$ and $\beta_2 < 0$ then $\partial Y/\partial STX$ will eventually be negative as STX increases. Clearly, $\partial Y/\partial STX < 0$ when $STX > -(\beta_1/2\beta_2)$. The same conditions hold for HR. The parameter estimates for STX^2 and HR^2 are indeed negative indicating that the functions turn down rather than explode with increasing values of STX and HR.

The variable IM was dropped from the model since imports were highly correlated (negatively) with exports

Table 5.3. Estimates for the Initial Constant Period From Maturity Models.

Variable	two month model	four month model	six month model
intercept	1.430 (.701)[a]	-.960 (.583)	-.085 (.599)
EX	-3.352 (.531)	-3.499 (.484)	-4.321 (.508)
ML	-5.492 (.861)	-5.979 (.934)	-4.912 (1.113)
HR	11.090 (3.798)	11.775 (3.680)	10.213 (3.843)
HR^2	-8.886 (3.123)	-9.116 (3.037)	-7.875 (3.170)
P1	-6.197 (.896)	-5.908 (.855)	-5.113 (.893)
P2	-2.029 (.720)	-2.123 (.690)	-2.019 (.731)
STX	.416 (.737)	3.212 (.770)	.792 (.765)
STX^2	-.262 (.344)	-1.309 (.350)	-.204 (.356)
adjusted R^2	.56	.56	.50
F statistic	65.59	64.81	52.21
observations	411	395	408
d.f.	403	387	400

[a] Uncorrected standard errors shown in parentheses.

resulting in insignificant parameter estimates. The signs of the other parameter estimates are as hypothesized. The overall fit of the two, four and six month models gave corrected R squares ranging from .50 to .57.

In order to test the model for heterscedasticity using the procedure discussed in Chapter IV, the estimated residuals from the first set of regressions were then squared and regressed against commodity dummy variables. The results of the dummy variable regressions are shown in Table 5.4. Soybean crush, which refers to the form transformation of crushing soybeans into soybean oil and meal, was used as the base. The parameter estimates for all commodities except oats are highly significant as can be seen by the T values in parantheses. This result indicates that the mean value of the squared errors for all of the commodities except oats are significantly different from those of the soybean crush. This is evidence that the residuals in the first regressions are heteroscedastistic (at least with respect to soybean crush) and their variances are related to unobserved commodity characteristics that have not been included in the model.

The square roots of the coefficients, the a_i's in the dummy variable regressions, are the mean values of Table

Table 5.4. Estimates for the Regression of Commodity Dummy Variables on the Squared Estimated Residuals from the Initial Regression (in Table 5.3).

Commodity dummy	two month model	four month model	six month model
intercept (SB crush)	5.87 (20.40)[a]	6.47 (19.12)	6.34 (18.45)
Corn	-2.36 (-5.73)	-4.14 (-9.11)	-3.39 (-6.88)
Wheat	-4.80 (-11.64)	-5.47 (-12.05)	-5.29 (-10.72)
Oats	.18 (.36)	-.76 (-1.41)	.12 (.20)
Soybeans	-4.01 (-9.72)	-5.02 (-11.06)	-4.40 (-8.95)
Cattle	-5.18 (-11.66)	-5.69 (-11.69)	-5.52 (-10.37)
Frozen pork bellies	-4.86 (-11.16)	-5.02 (-10.54)	-5.04 (-9.72)
FCOJ	-2.16 (-4.79)	-2.59 (-5.31	-2.58 (-4.82)
adjusted R^2	.41	.41	.36
F statistic	42.55	39.76	33.35
observations	411	395	408
d.f	404	388	401

[a] T statistics shown in parentheses.

the estimated residuals for each commodity from the first regressions. These coefficients provide an estimate of the heteroscedastistic nature in the model, that is, an estimate of the multiplicative constant, a, discussed in Chapter IV. These estimates, one per commodity as shown in Table 5.5, are then used to weight the original equations so that the variance is homoscedastistic (see Chapter IV).

Weighted Least Square Results

The equation specified in (5.1) is transformed by the parameter estimates shown in Table 5.5. Specifically, each observation corresponding to a particular commodity (i) is divided by the corresponding a_i in Table 5.5. This transformation produces a model that must be estimated without an intercept term since the intercept in the original model is now $1/a_i$. Interpretations of the coefficients in the weighted equations are the same as in the original specification (Table 5.3) since the transformation does not lead to a respecification of parameters associated with the original variables except for the intercept, which is not associated with $1/a_i$ in the weighted least square equation.

The weighted least squares (WLS) results are reported in Table 5.6. The overall fit in each of the three models is acceptable with the adjusted R2's in the two, four and six month models being .88, .89 and .87

Table 5.5. Heteroscedasticity Adjustment Coefficients.

Commodity (i)	Heteroscedasticity adjustment Coefficient (a_i)
Soybean crush	2.42
Corn	1.87
Wheat	1.03
Oats	2.46
Soybeans	1.36
Cattle	0.83
Frozen pork bellies	1.00
FCOJ	1.93

Table 5.6. Weighted Least Squares Estimates for the Basis Residual Variance Model After Correcting for Heteroscedasticity.

Variable	two month model	four month model	six month model
1/a	.71	-.89	-.45
	(1.48)[a]	(-2.11)	(-1.09)
EX/a	-3.27	-2.99	-4.05
	(-7.98)	(-7.70)	(-10.05)
ML/a	-3.44	-3.79	-2.41
	(-5.97)	(-5.84)	(-3.32)
HR/a	4.18	5.16	.61
	(1.62)	(1.95)	(.23)
HR^2/a	-3.59	-4.39	-1.26
	(-1.59)	(-1.95)	(-.54)
P1/a	-4.47	-4.50	-2.74
	(-7.43)	(-7.26)	(-4.36)
P2/a	-.67	-.83	-.02
	(-1.47)	(-1.74)	(-.37)
STX/a	1.27	3.07	1.99
	(2.13)	(5.10)	(3.20)
STX^2/a	-.68	-1.35	-.744
	(-2.90)	(-4.84)	(-2.55)
adjusted R^2	.88	.90	.87
F statistic	326.55	382.71	303.81
observations	412	396	409
d.f.	403	387	400

[a] T statistics shown in parentheses.

respectively. The results concerning the specific parameter estimates are now discussed.

Exports. The variable exports (EX) is defined as exports divided by total domestic production and is based on yearly data for the various commodities. As shown in Table 5.6, the parameter estimates are highly significant in the two, four and six month models. As hypothesized, the coefficients for exports have negative signs.

It is helpful to examine industry structure in order to explain why higher relative exports act to integrate the cash and futures markets, thereby decreasing the variability in the basis residual. The export industries for agricultural commodities in the present analysis aggregate commodities on a grand scale for export sale. These marketing functions are carried on by large corporations located in major ports in the Great Lakes region and New Orleans. The large exporting firms transact in great volume and high value inventories. The risk associated with commodity price changes can be considerable given the value of the large inventories. Through hedging, the futures markets can be used to reduce the risk of price fluctuations in the cash market. For example, in order to insulate themselves from cash price changes in the interim, firms can buy futures contracts at a known price to cover a contract to deliver an export commodity at a corresponding future date.

Because of the high value of the inventories and transactions involved, exporting firms have the incentive to devote significant resources to keep abreast of current situations in the cash and futures markets. These firms have the resources to employ market analysts to guide them in their marketing decisions. The result is aggressive arbitrators that quickly seize any profit opportunities that may arise between the cash and futures markets. It is these buying and selling activities of informed market participants that act to integrate the cash and futures markets, as reflected with the parameter estimates for EX. This integration results in decreased variability in the basis residual or improved market performance. The greater amount of a commodity that is exported, the greater the interest in arbitrating between the cash and futures markets.

In contrast, the degree of terminal market aggregation for the portions of commodities that are not exported is not nearly as great as with exports. For instance, the marketing channels for oats, a commodity for which exports make up a small percentage of consumption, are much less centralized than that of exported wheat (see Table 5.2). When there are a relatively great number of smaller sized firms or cooperatives carrying on the marketing function, these smaller firms do not have the same resources or incentives to devote to market analysis that large exporting firms do. In addition, because of location, the large exporting firms may be in a better situation to make or accept delivery on a futures contract, that is, their potential to physically arbitrate is greater. Therefore, as a result of the inherent large scale marketing structure for commodity exports, export activity acts to improve the integration between the cash and futures markets.

Market liquidity. Market liquidity (ML) reflects the ease of entry and exit in the futures market and is defined as trading volume divided by open interest, as specified in equation (4.9). As shown in Table 5.6, the parameter estimates for ML are highly significant in the two, four and six month models. As hypothesized, the estimated coefficients for market liquidity have negative signs in all three models. That is, a liquid market facilitates the potential to arbitrate so that abberations in the relationship between the cash and futures market can be corrected. Thus, liquidity acts to reduce variability in the basis residual or enhance market performance.

In a thin market that lacks liquidity traders incur higher costs in order to establish or close out futures positions because they are not able to trade without incurring some price premium or discount, depending on their trading intentions. These excess costs act to decrease the integration between the cash and futures markets. In contrast, a liquid market facilitates trading so that potential arbitrators can respond quickly and with the least cost to basis levels that are not consistent with the cost of transformation. For instance, in a liquid futures market an elevator operator can take advantage of a basis level that is greater than the cost of storage (plus the brokerage commission incurred by establishing a futures position) by buying the cash commodity and selling futures. However, the operator's ability to arbitrate in this manner depends on being able to consummate the sale of the futures contract. A thin market may simply lack sufficient trading activity for this transaction to take place and hence, the wide basis may persist.

Table 5.2 shows the mean values of market liquidity for the various commodities in the present analysis. Market liquidity increases going from the six month to the two month model since volume of trading tends to increase as maturity approaches. The more liquid markets include cattle and frozen pork bellies with the soybean market having the highest liquidity among the grain group. Frozen concentrated orange juice represents the least liquid market in the analysis. Ward (1974) examines liquidity in the FCOJ futures market and emphasizes the importance of commercial interest (hedging) in supporting the volume necessary to make a contract viable.

Hedging ratio. The hedging ratio (HR) is based on quarterly trading data for each commodity from the Commodity Trade Commission. As discussed previously, this variable is defined as hedged positions divided by total reported positions. Since not all positions are reported as hedged or speculative, the total number of hedged contracts was estimated by apportioning the nonreported positions according to the allocating scheme developed by Ward and Behr (1983a). This procedure was discussed in Chapter IV and summarized in equations 4.10 and 4.11.

The hypothesized sign for HR is negative since a relative increase in hedged positions is expected to increase the arbitrage potential and therefore, decrease the variability in the basis residual. As shown in Table 5.6, the parameter estimates in all three models are positive for HR and negative for HR^2 revealing that the function initially increases then decreases. The parameter estimates for HR and HR^2 are significant at the ninety percent level in the two and four month models and insignificant in the six month model.

The results above imply that some threshold level or "critical mass" of hedged positions is needed before this factor can act to reduce basis variability. By solving for the turning point in the HR function we find that this threshold level occurs close to the mean value of HR in the two, four and six month models. Once the hedge ratio is above the mean then an increase in the ratio of hedged positions to total positions significantly decreases the variability in the basis residual. The properties of this function are considered in greater detail in the following chapter.

The turning points in the two, four and six month models range from an HR value of .48 to .59 while the mean value of the hedge ratio over the commodities in the data set is .51. The results suggest that when a market is highly speculative then slight increases in the number of hedged positions relative to total trading is not sufficient to improve the integration between the cash and futures markets, that is, speculation is still the dominant force in the futures market. For increases in the hedge ratio beyond the point at which hedging makes up approximately 50 percent or more of the traded positions, then the integration between the two markets strengthens. This is not to say that speculation reduces market performance. Speculators add market liquidity which was shown in the previous section to have a beneficial effect on market performance. The above observation does suggest that strong commercial interest in a market, where HR is greater than or equal to fifty percent, is needed before additional hedged positions significantly strengthens the arbitrage potential.

It is likely that the hedge ratio was not significant in the six month model because of the way in which hedging is necessarily defined in the data. Data on futures trading are recorded as hedging, speculation or nonreported but of course the time horizon corresponding to the hedged positions is not considered. Therefore, the quarterly data on the hedging ratio used in the analysis is the same for the two, four and six month models. The insignificance of HR in the six month model most likely occurs because the data on the hedge ratio do not temporally align with a basis representing six months from maturity. For instance, it is not surprising that a hedge placed two months from maturity would not increase the integration between the cash price and a futures price six months from maturity because the arbitrage potential resulting from the two month hedge does not apply to the six month time interval. The strong significance of the hedging ratio in the two and four month models and insignificance in the six month model indirectly suggests that hedges, as reported by the Commodity Futures Trading Commission, are placed for approximately four months or less.

Perishability. Three degrees of perishability were identified and treated as dummy variables. P1 corresponds to the most storable commodities and includes the grains, the soybean crush transformation and frozen concentrated orange juice. P2 represents frozen pork bellies which can only be stored for six months. The omitted dummy variable or the intercept corresponds to the most perishable commodity, fresh beef.

The results in Table 5.6 show that the coefficient for P1, storable commodities, is highly significant in all three models, that is, the variance in the dependent variable is significantly different for the storable classification compared to the perishable classification. The semistorable classification is significant only in the four month model. This insignificance suggests that the distinction of semistorability in the case of frozen pork bellies is not strong enough to result in a variance structure in the dependent variable that is significantly different from the variance associated with the perishable classification.

By solving for the different designations of storability using the parameter estimates for P1, P2 and the intercept, we can see the effect that the three levels of storability have on different CPM models. These results for the two, four and six month models are shown in Table 5.7.

In all three models the mean level of variability in the basis residual is significantly higher for the nonstorable as compared to the storable classification. This result was expected because holders of storable products have greater flexibility in timing their marketing than producers of nonstorables. Since factors that affect marketing flexibility influence the arbitrage potential, storability was expected to improve market performance as reflected in the variability of the basis residual.

Another anticipated result can be seen by comparing the two and six month models in Table 5.6. The difference in the variability of the basis residual between storable and nonstorable is much greater in the two month model than it is in the six month model. Recall that the cattle basis represents the form transformation of feeding a 600 lb. animal to a finished weight of 1100 lbs. This transformation takes

Table 5.7. Mean Levels of the Standard Deviation of the Basis Residual Corresponding to Alternative Classifications of Storability.

	two month model	four month model	six month model
Storable	.023	.005	.041
Semistorable	1.044	.179	.629
Nonstorable	2.040	.410	.640

approximately four to six months to complete. In Chapter III, T is used to denote the time necessary to complete a transformation and t represents the time interval defined by the basis.

In the two month model t is less than T for the nonstorable since a 600 lb. animal can not be fed to market weight in a two month period. Thus, there is no potential to arbitrate between the cash market for feeder cattle and the futures market for live cattle, in the two month model. This inability to arbitrate potentially results in poorer integration between the markets, leading to higher variability in the basis residual.

Alternatively, since t is greater than or equal to T in the six month model, the potential to arbitrate exists. That is, feeder cattle can be purchased in the cash market, fed and potentially delivered to fulfill a futures contract for live cattle six months in the future. The results support this argument since difference in the variability in the basis residual between nonstorable and storable is much greater in the two month model than in the six month model. That is, market performance for nonstorables relative to storables improves in the six month model compared to the two month model. Since the dependent variables in the two, four and six month models are different, direct comparisons among the models is not possible using standardized statistical procedures.

Stocks. The variable STX represents quarterly stock levels relative to yearly mean stock levels. This variable is defined as the stock level in the k^{th} quarter divided by the mean stock level for the corresponding year for each commodity. The hypothesized sign for STX is negative since the potential to arbitrate should increase with an increase in available stocks.

As in the case of the hedge ratio, the sign on STX was positive. For theoretical consistency a squared term was added to the model to provide greater flexibility in measuring the stock effect. The results for STX and STX^2 are shown in Table 5.6. The parameter estimates are positive for STX and negative for STX^2 in the two, four and six month models and are significant in all three models.

Solving for the turning points in each of the models reveals that in the two month model, the function increases up until a STX value of .94 and then decreases. In the four and six month models these turning points occur at 1.14 and 1.34 respectively. Insight into the likely cause of the unanticipated initial increasing portion of the STX function can be gained by examining the data characteristics more closely.

As a result of seasonal production patterns, stock accumulation and depletion follow seasonal patterns for the agricultural commodities in the present analysis. For the storable commodities, that is, the grains and frozen concentrated orange juice, stock levels are highest following harvest, after which supplies are depleted throughout the year until stock levels typically reach their lowest point just prior to the next harvest.

Correspondingly, information about crop production follows seasonal patterns because seasonal weather patterns dictate production in agriculture. A particularly critical time for most crops is the late summer months when rain or lack of rain has a significant effect on crop yields. Anderson (1985) cites these months as the period of time when the greatest degree of uncertainty about market conditions is resolved. He empirically shows that it is during this time period that futures price volatility is greatest. Livestock markets are also affected by this uncertainty since grains are a major input to livestock production.

Stock levels and the resolution of uncertainty about production each follow seasonal patterns that are similar year after year. The contemporaneous correlation between stock levels and the high level of futures price variability that occurs in the late summer is likely to be responsible for the increasing portion of the STX function. This function confounds the affects of stocks and the resolution of uncertainty prior to the turning point. For instance, stock levels in July are greater than stock levels in September. But uncertainty about crop yield is substantially greater in July than September, causing the general level of futures price variability to be greater in July than September. The positive affect of uncertainty on price volatility dominates the negative effect that stock levels have on the variability of the basis residual, resulting in an increasing portion in the STX function.

Since the stock levels corresponding to the late summer typically occur at levels below each of the turning points in the three models, increases in the stock index beyond the turning point decrease variability in the basis residual, as expected. This portion of the function shows the beneficial effect that increased stock levels have on market performance by improving the potential to arbitrate between the cash and futures markets. The actual curvature of this function along with those corresponding to the other exogenous variables are depicted in the following chapter.

Model Overview

The basis residual variance model has now been quantified and discussed at some length. However, to fully grasp the relationships and their practical implications, it is fruitful to simulate market conditions over a range of variable values. In the next chapter, detailed simulations are reported along with a discussion of their relevant implications to basis performance.

CHAPTER VI
SIMULATION WITH THE BASIS RESIDUAL VARIANCE MODEL

The empirical results in the two, four and six month constant period from maturity models are used in this chapter to investigate in further detail the estimated effects that the exogeneous variables have on arbitrage potential. Specifically, response functions that simulate the effect that each independent variable has on the variability of the basis residual are developed for the three CPM models. In addition, elasticity measures of arbitrage potential with respect to the various exogeneous variables are examined. These simulations will give further insight into the relationships between the dependent and independent variables and their corresponding implications for basis performance.

Arbitrage Response Functions

The parameter estimates from the weighted least squares regressions (Table 5.6) are used to simulate the response functions shown in Figures 6.1 - 6.12. The partial derivatives for the two, four and six month models are generated by parameterizing an independent

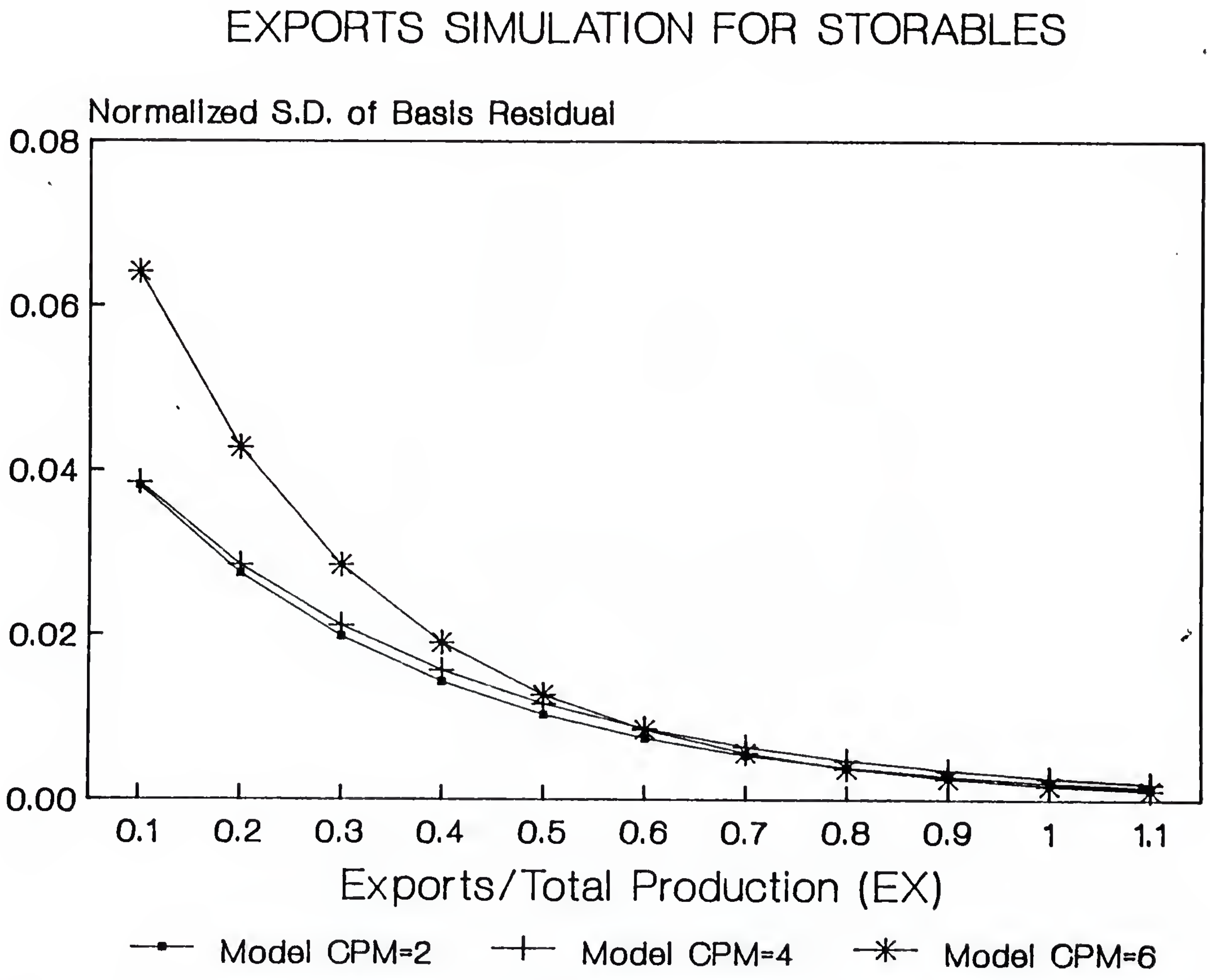

Figure 6.1. Effects of Exports on the S.D. of the Basis Residuals for Storables.

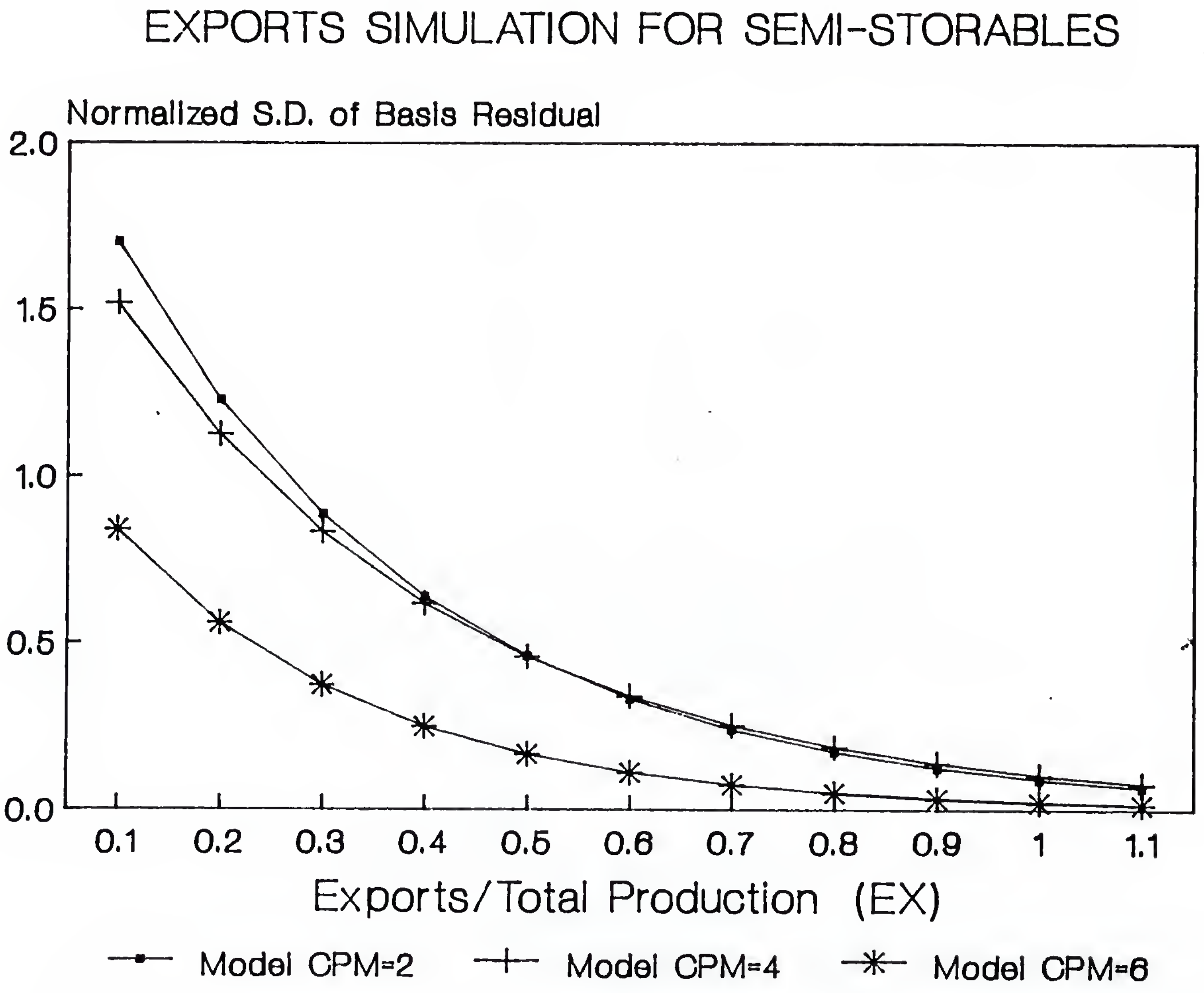

Figure 6.2. Effects of Exports on the S.D. of the Basis Residuals for Semi-storables.

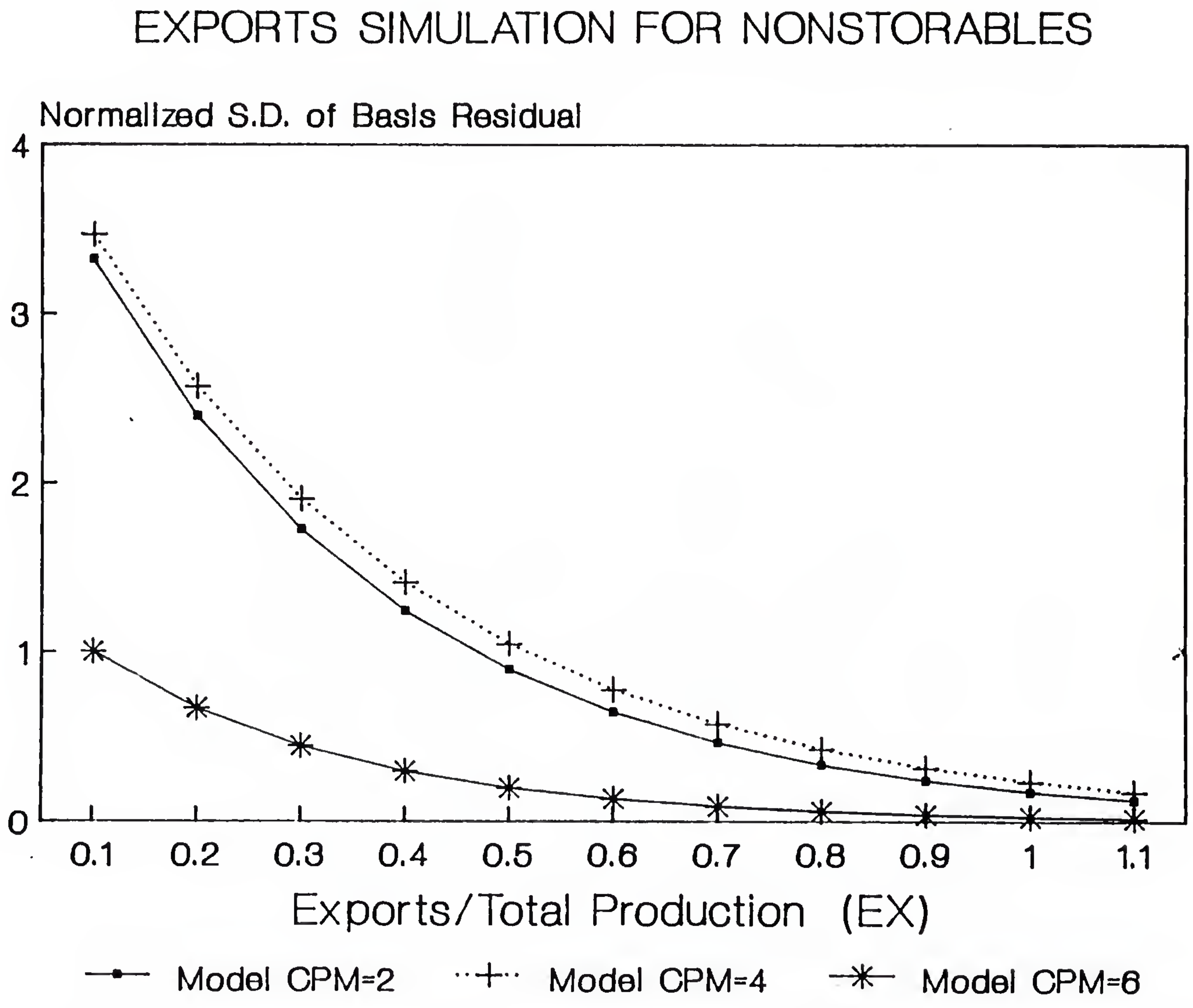

Figure 6.3. Effects of Exports on the S.D. of the Basis Residuals for Non-storables.

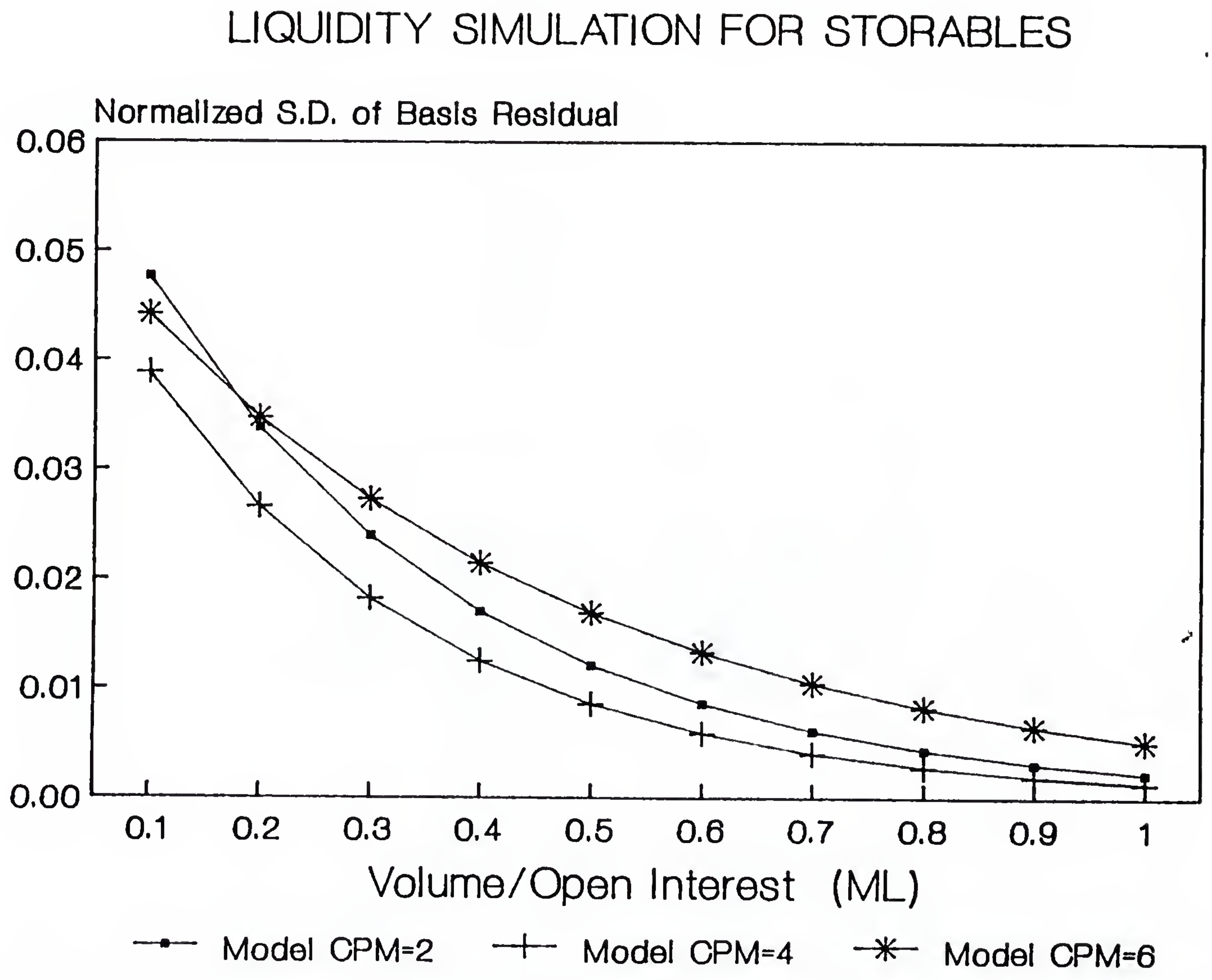

Figure 6.4. Effects of Liquidity on the S.D. of the Basis Residuals for Storables.

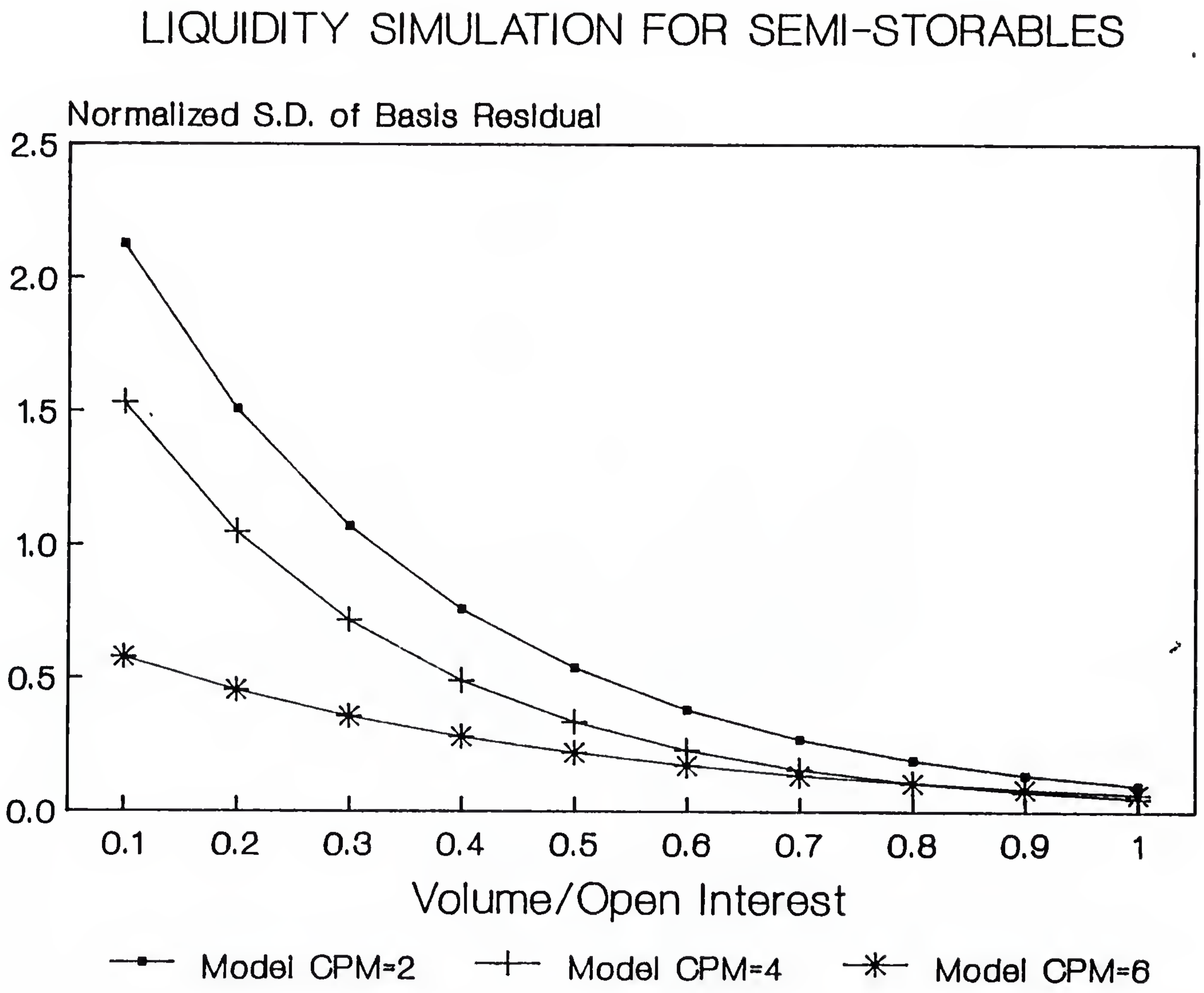

Figure 6.5. Effects of Liquidity on the S.D. of the Basis Residuals for Semi-storables.

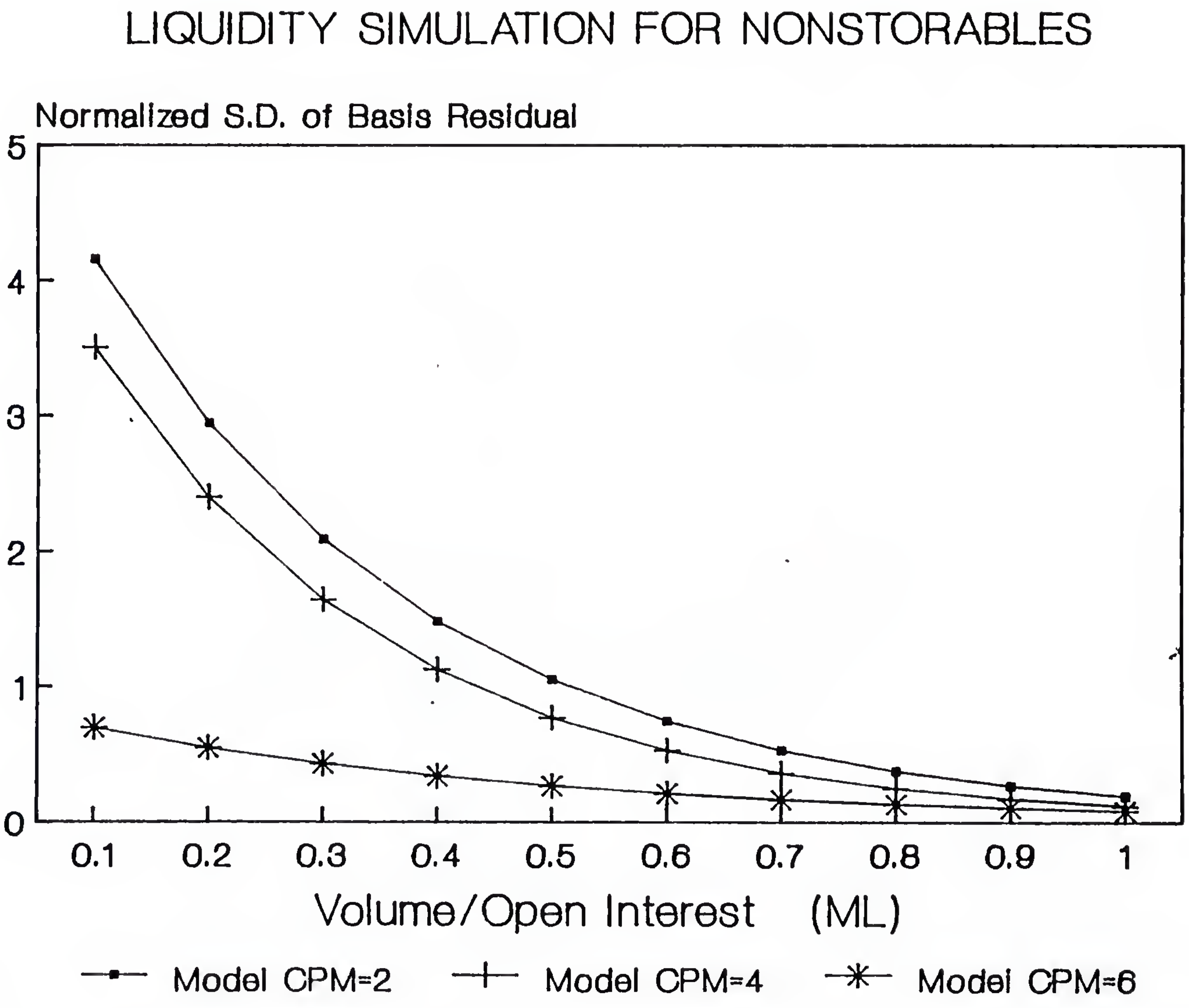

Figure 6. 6. Effects of Liquidity on the S.D. of the Basis Residuals for Non-storables.

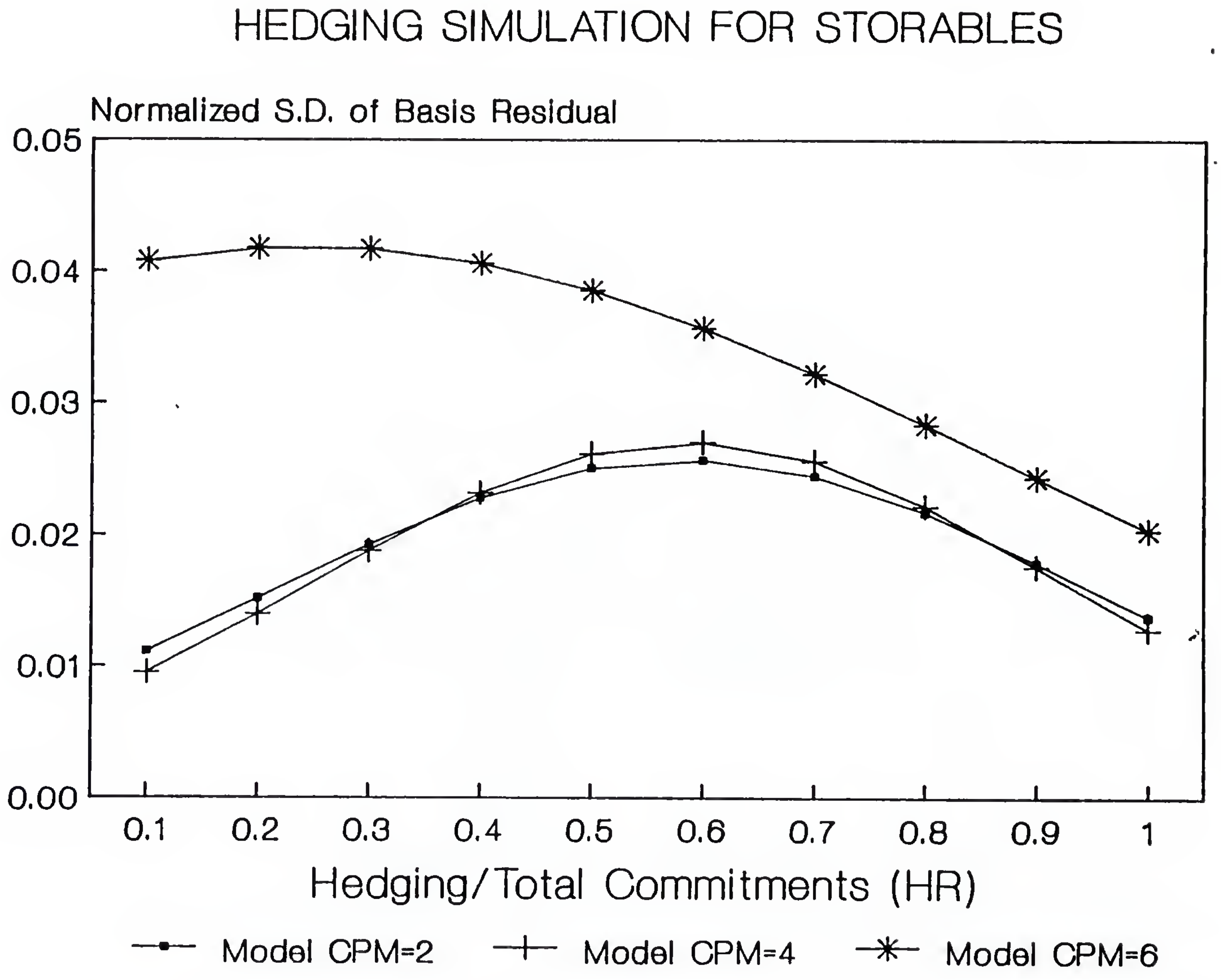

Figure 6.7. Effects of Hedging on the S.D. of the Basis Residuals for Storables.

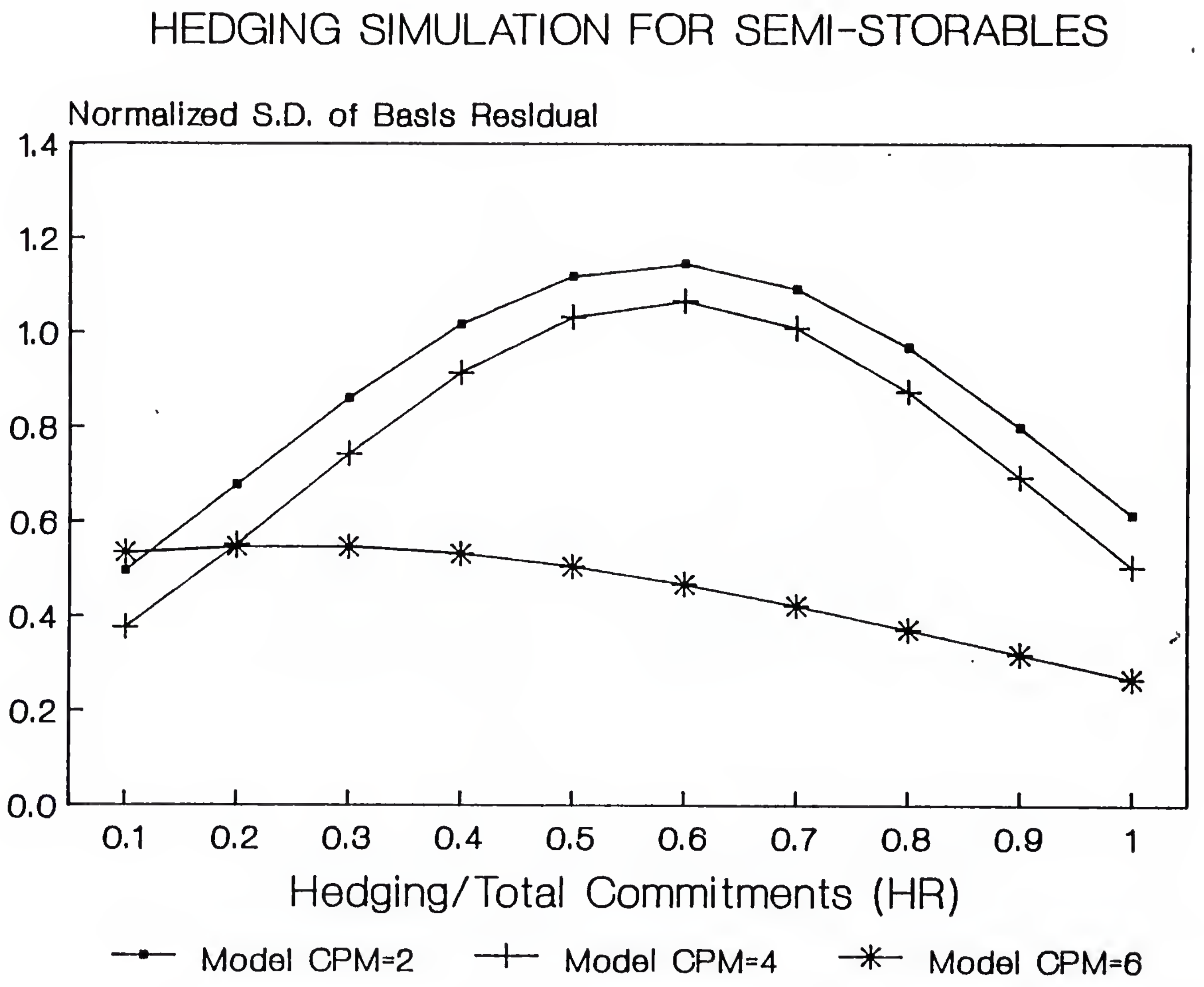

Figure 6.8. Effects of Hedging on the S.D. of the Basis Residuals for Semi-storables.

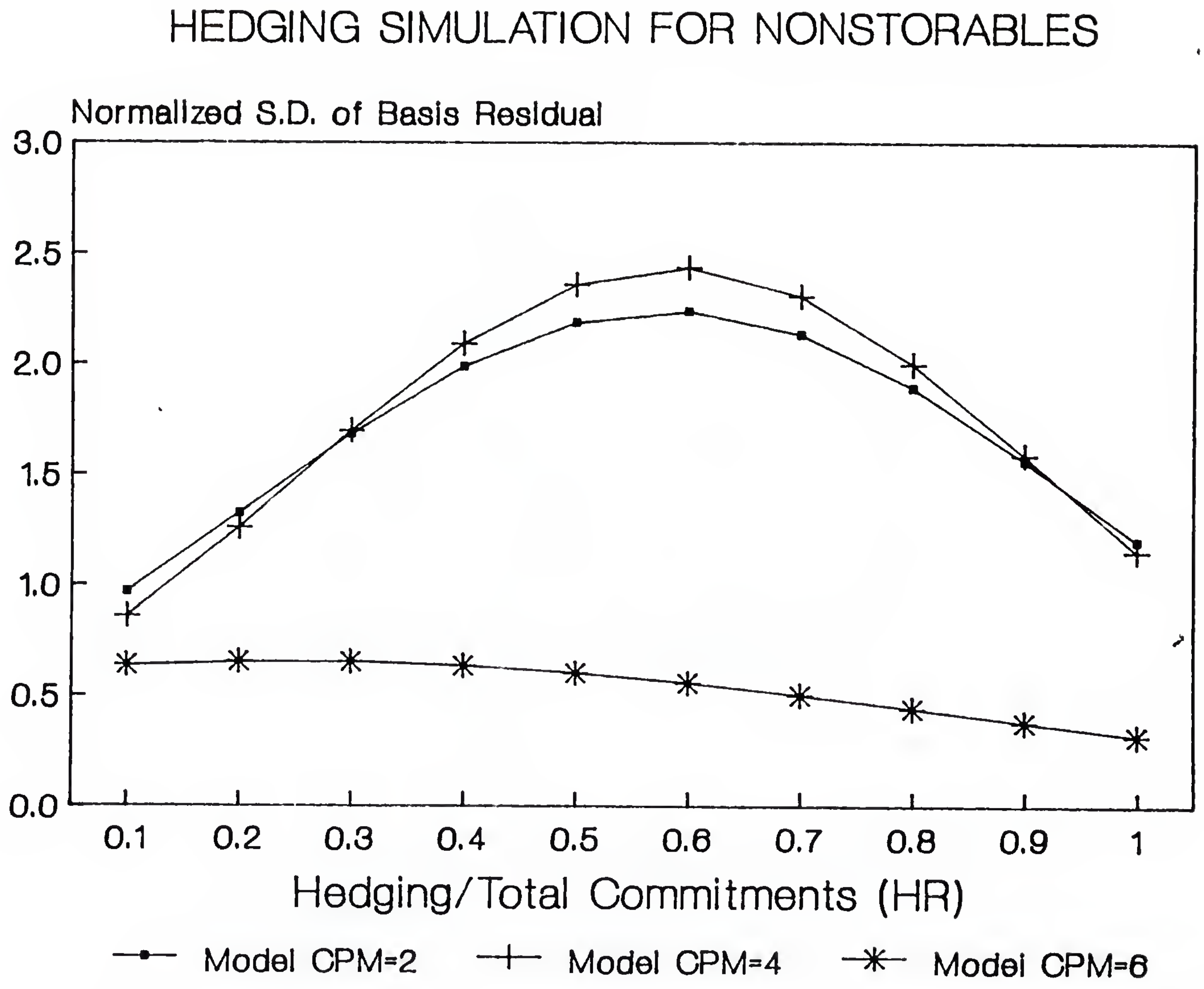

Figure 6.9. Effects of Hedging on the S.D. of the Basis Residuals for Non-storables.

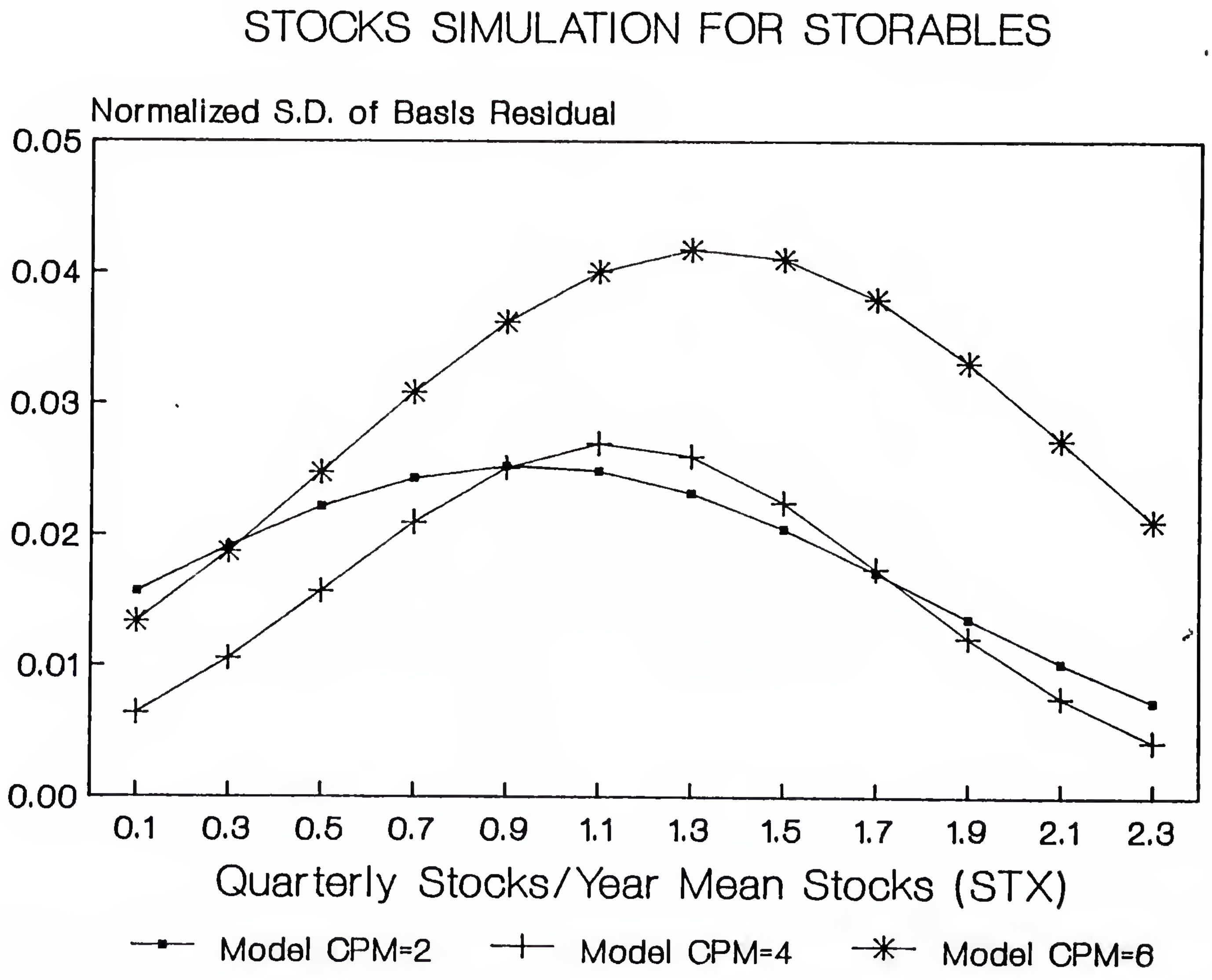

Figure 6.10. Effects of Stocks on the S.D. of the Basis Residuals for Storables.

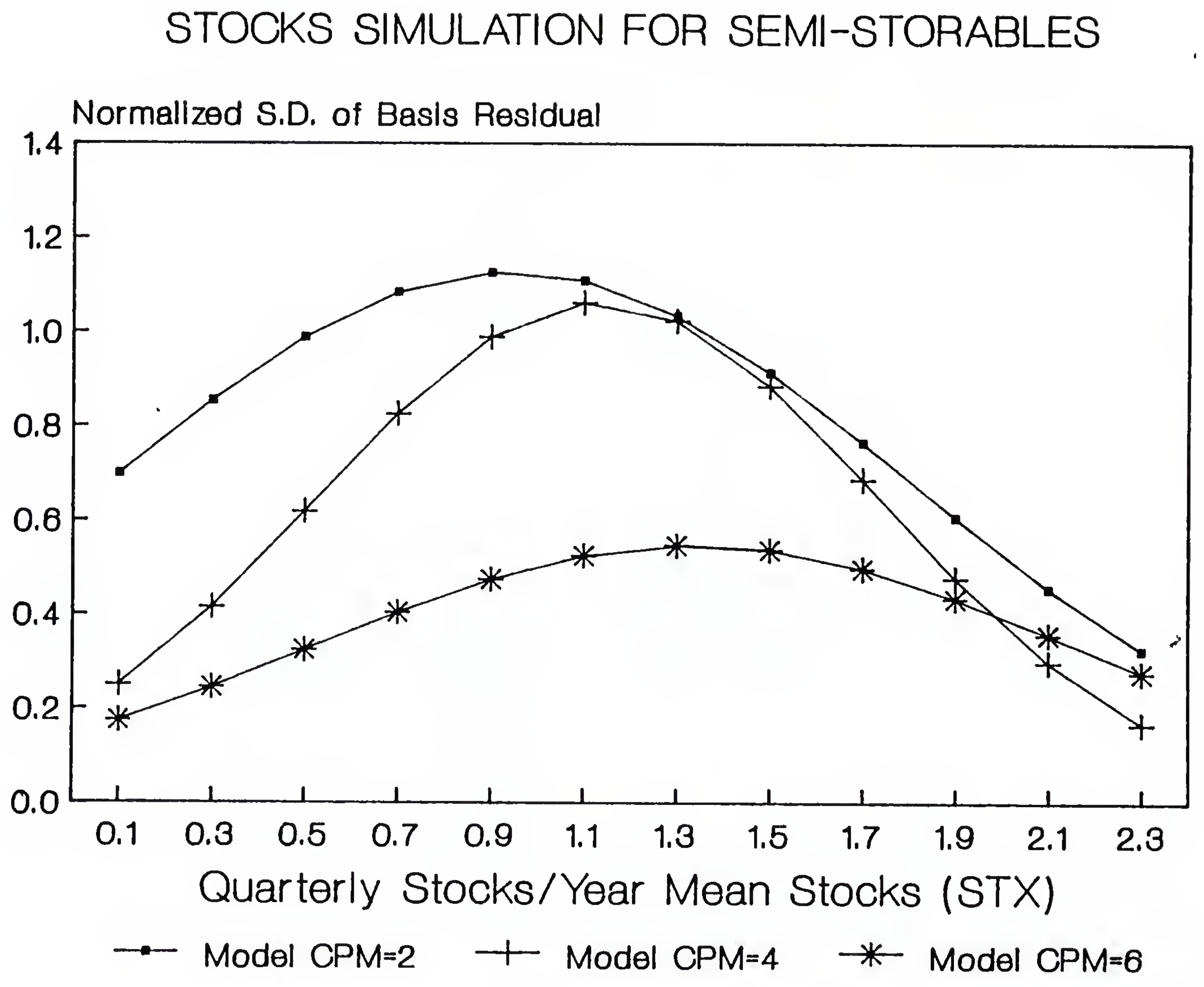

Figure 6.11. Effects of Stocks on the S.D. of the Basis Residuals for Semi-storables.

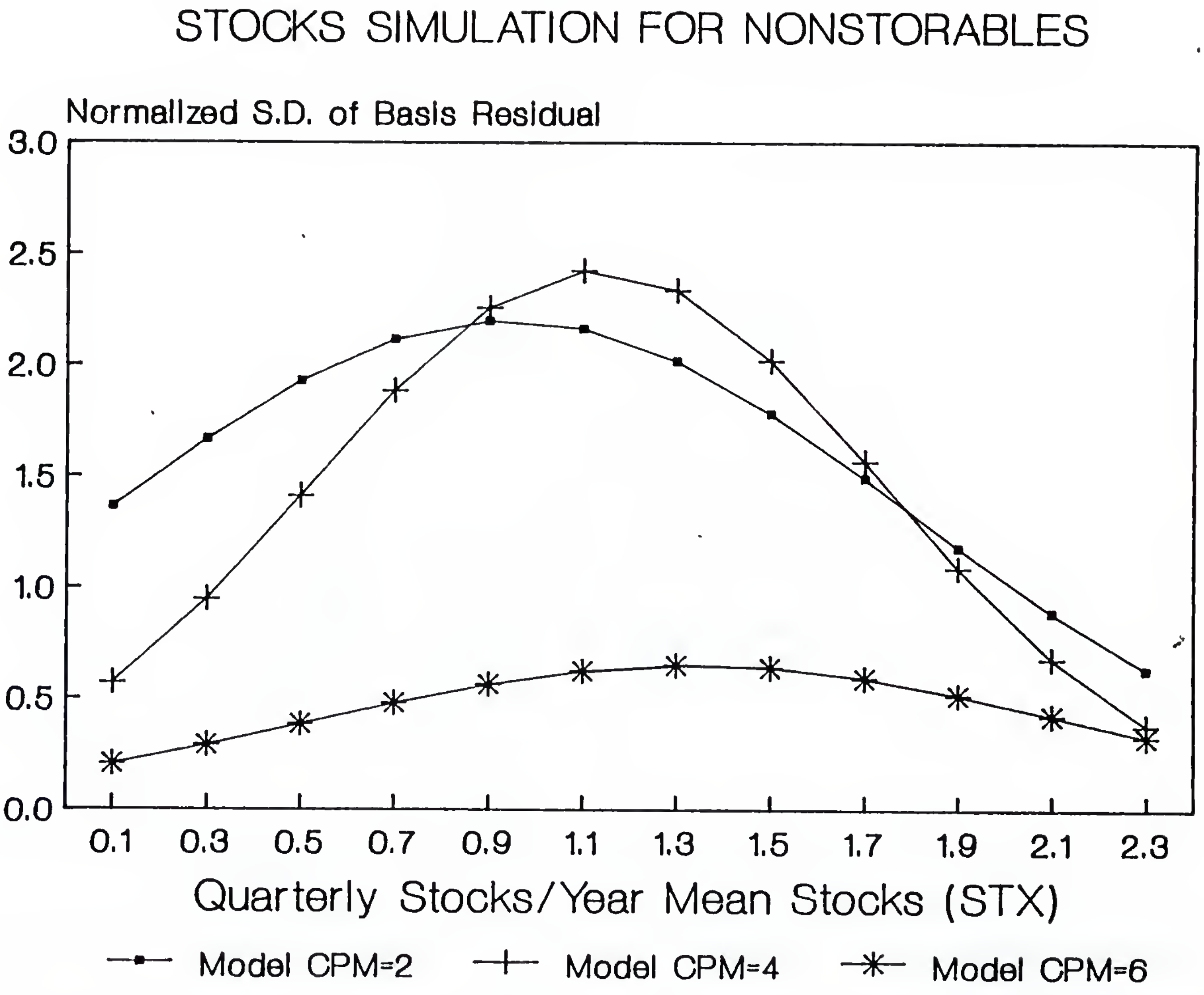

Figure 6.12. Effects of Stocks on the S.D. of the Basis Residuals for Non-storables.

variable over the range in which it occurs in the data set while holding the other independent variables at their mean levels.

Each graph superimposes the plots of the two, four and six month models where the vertical axis represents the values for the normalized standard deviation of the basis residual for each of the CPM models. Recall that the dependent variable is defined as the standard deviation of the basis residual divided by the standard deviation of the cash price [SD(BR)/SD(P)] and reflects the integration between the cash and futures markets. Lower values of the dependent variable are associtated with better market performance than higher values.

For each independent variable there are three graphs, namely a, b and c, corresponding to the three classifications of storability. The storable group includes the grains and frozen concentrated orange juice, while the semistorable and nonstorable classifications correspond to frozen pork bellies and cattle, respectively. The simulation is shown for each level of perishability since this is the only discrete variable in the model and it is meaningless to discuss a mean perishability level. While the graphs in each section are discussed primarily in the context of the variable being simulated, adequate attention will be given to the implications resulting from changing perishability. The results of the two, four and six month models are compared, however, it is noted here that a statistical comparison among the three models, where the dependent variables are different, can not be completed since the models where estimated with potentially different distributional properties in the residuals. The simulations are discussed in the order in which the variables appear in Table 5.6, that is, EX, ML, HR, and STX.

Exports

Exports are defined as exports divided by total domestic production. An export value of .6 indicates that 60 percent of total production is exported. Figure 6.1 shows the effect of exports on the variability of the basis residual for the case of nonstorables in the three CPM models. All three functions are negatively sloped revealing that an increase in exports would be expected to improve the arbitrage potential or enhance market performance in the two, four and six month models.

In the previous chapter it was argued that exports benefit the arbitrage potential because large exporting firms have the resources and incentive to keep abreast of market conditions and the potential to arbitrate between the cash and futures markets if a profitable opportunity arises. The functions in the two and four month models are quite similar while the function in the six month model begins at a higher level of variability then decreases at a faster rate until an export level of .5.

The mean level of exports over all the commodities in the analysis is .23. Returning to Table 5.2, it is interesting to look at where the mean export values for the various commodities lie in relation on the graph. For the storable commodities, oats and FCOJ exports are very low at the extreme left, whereas the mean export value of wheat is .61. The mean export values for corn and soybeans are .26 and .39, respectively. The curvatures of the three functions imply that the greatest relative benefit from increased exports occurs at the lower levels of exports for commodities such as oats, FCOJ and corn, in all three models.

The export simulations for the semistorable and nonstorable classifications are shown in Figures 6.2 and 6.3. Since the parameter estimate for the semistorable dummy variable (P2 in Table 5.6) is insignificant, it is not surprising that the results are very similar in the semistorable and nonstorable graphs. While the graphs in Figures 6.2 and 6.3 have similar patterns, the general level of variability associated with the nonstorable classification is higher than that of the semistorable classification. That is, the integration between the frozen pork bellies cash and futures markets is greater than the integration between the feeder cattle cash market and the live cattle futures market for all three CPM models.

Looking at Figure 6.3, it is apparent that the variability in the six month model is much lower than in the two and four month models. This relationship among the three CPM models for nonstorables occurs throughout the various simulations of exogeneous variables because in the six month model enough time elapses that feeder cattle can be purchased and fed out to market weight. This transformation is not physically possible in the time frame corresponding to the two and four month models so that the potential to arbitrate between the markets is considerably less. The integration between the markets is much stronger in the six month model than in the two and four month models. Finally, the mean value of beef exports is .004. Although it may not be likely to occur, these results suggest that an increase in beef exports relative to production will enhance the arbitrage potential. Realistically, there are limits in terms of the percentage of beef production that could be exported.

Market Liquidity

Market liquidity (ML) is defined as trading volume divided by open interest and reflects the ease of entry and exit in the futures market. Figure 6.4 shows the beneficial effect that increased liquidity levels have on the arbitrage potential for storable commodities. The functions, which are negatively sloped throughout, are very similar across the three CPM models. The mean levels of liquidity across all commodities in the analysis decline when moving from to two month model to the six month model. That is, the overall mean liquidity level is .29 in the two month model, .20 in the four month model and .16 in the six month model. Therefore, trading activity increases as contract maturity approaches.

The curvature of the functions indicate that market performance could improve significantly for increases in market liquidity above the mean levels, in all three models shown in Figure 6.4. However, the ratio of hedgers to speculators that make up the trading activity must also be considered before the effect of increased market liquidity can be fully ascertained (Ward, 1974). This topic will be considered in the following section. For the storable commodities, FCOJ is the least liquid market with a mean liquidity level of .12 in the two month model, while soybeans is the most liquid with a mean liquidity level of .37 in the two month model.

As before, the functions in Figure 6.5 corresponding to semistorable and those in Figure 6.9 corresponding to nonstorable are very similar except that the overall level of variability is higher for the nonstorable than the semistorable classification. Also as before, the arbitrage potential for the nonstorable in the six month model is substantially greater than in the two or four month models, as seen in Figure 6.6.

Referring back to Table 5.1, the mean liquidity value is .51 for frozen pork bellies, the most liquid market in the analysis, and .35 for live cattle, each for the two month model. The mean liquidity levels in the two and four month models in both Figures 6.5 and 6.6 occur at points on the functions which are declining at a relatively fast rate. The results imply that increases in liquidity above the means in the two and four month models would significantly reduce variability in the basis residual for both semistorable and nonstorables, however, since the liquidity function is relatively flat in the six month model one would expect relatively small gains from increases in liquidity beyond the current mean level.

Hedging Ratio

The hedging ratio (HR) is defined as hedged positions divided by total reported positions, as shown in equations (4.10) and (4.11). Figure 6.7 shows how the variability in the basis residual responds to varying levels of the hedge ratio in the case of storables. The

HR function in the six month model, which declines almost immediately, is dissimilar to the two and four month models in which the HR functions have a turning point at a higher HR level. However, as discussed in Chapter V, the parameter estimates for HR and HR^2 are significant in the two and four month models but insignificant in the six month model, which may account for the notable difference in the curvature of the six month function.

The mean HR over all the commodities is approximately .51 and the HR functions in the two and four month models begin to decrease at an HR level of approximately .60. The curvature of these functions imply that a certain threshold in the ratio of hedged positions is necessary before an increase in the hedging ratio can have a beneficial effect on market performance. For increases in the HR just beyond the mean level, the variability in the basis residual declines and performance improves. As can be seen from Table 5.2, storable commodities have higher mean hedge ratios than the semistorable and nonstorable commodities. Corn has the highest mean HR of .73.

Figures 6.8 and 6.9 show the similar results for the semistorable and nonstorable classifications. The mean HR level for live cattle futures is .37 and only .12 for frozen pork bellies. The results suggest that in the six month model, an increase in the hedge ratio beyond the mean would improve the integration between the feeder cattle cash market and the live cattle futures market, however, as mentioned above, the coefficients for HR and HR^2 are insignificant in the six month model. The curvatures of the two and four month functions in Figure 6.9 imply that a dramatic increase in HR beyond its current mean level would be necessary to decrease the variability in the basis residual for cattle.

Stock Index

The stock index (STX) is defined as the quarterly stock level divided by the average annual stock level in the corresponding year and thus expresses stock levels in relation to the other quarterly levels within that year. While increased stock levels are expected to improve the arbitrage potential, in Chapter V the rising portion of the STX curve was attributed to the contemporaneous correlation between stock levels and the resolution of uncertainty about crop production.

For the majority of grains, stock levels are lowest in the early fall just prior to harvest corresponding to the far left in Figure 6.10. At this point in time there is little uncertainty about crop yields and production for the upcomming harvest. In the summer months, stock levels are higher than in the early fall but there is a great deal of uncertainty concerning production about the next harvest since crop yields are very sensitive to weather conditions (e.g., rain or lack of rain) which are unpredictable. This high degree of uncertainty and its resolution result in elevated price variability which most likely influences the variability in the basis residual. The combination of these effects causes a rising portion in the STX curve. For the other quarters in the year when the uncertainty effect is not present, the STX curve has a negative slope as expected.

Referring to Figure 6.10, the variability in the basis residual is higher in the six month model than in the two and four month models. The uncertainty effect appears to have greater influence and last longer in the six month model than in the two and four month models. In addition, the financial risks of holding stocks for arbitration in the six month model are higher than in the two and four month models since interest rates can fluctuate more and capital is tied up for a longer period of time in the six month model.

In the case of the nonstorable commodity, live cattle, the stock index is defined in terms of cattle on feed because these animals represent forthcomming supplies. Cattle production occurs throughout the seasons but livestock markets are stongly influenced by the grain markets which account for the major input in cattle feeding. The influence of the grain markets may be responsible for the similarity in the curvature and turning points in the STX curves in Figures 6.12 and 6.10. As would be expected, the effect of the current relative number of cattle on feed is very small in the six month model since these cattle will be finished and consumed before the six month time period elapses.

Elasticity Measures

In this section the weighted least square results in the three CPM models are expressed in terms of elasticity measures. Elasticity functions are developed for exports, market liquidity, the hedging ratio and stocks. These functions are useful in understanding the relative effect that the exogeneous variables have on the variability of the basis residual

The elasticity of arbitrage with respect to each of the variables listed above is defined in 6.1

(6.1) $N_{ax} = \partial Y/\partial X * X/Y$

where Y is the normalized standard deviation of the basis residual [SD(BR)/SD(CP)] and X is an exogeneous variable. Given the exponential form of the regression equation, it follows that

(6.2) $N_{axi} = \beta_i * X_i$

where X_i corresponds to exports or market liquidity. For the hedging ratio and stock index which include squared terms,

(6.3) $N_{axj} = \beta_1 * X_j + 2 * \beta_2 * X_j^2.$

As can be seen in equations (6.2) and (6.3), under this model specification arbitrage elasticities do not depend on the other variables in the model, only on the variable under consideration.

Export Elasticity

As discussed in the preceeding sections, increases in exports relative to production enhance basis performance or decrease variability in the basis residual. Figure 6.13 shows the arbitrage elasticity--in absolute values--at varying export percentage (EX) levels. Export elasticities become more elastic with increases in EX. That is, the percentage decrease in the variability of the basis residual resulting from an increase in EX becomes greater at higher levels of EX.

As shown, the mean level of EX over all of the commodities occurs at .23 and corresponds to an arbitrage elasticity of .75 in the two month model. The relative effect of EX on basis performance is similar across the two, four and six month models as seen in the similarity of the three CPM functions. At one standard deviation away from the mean EX, the function is in the elastic region with a corresponding arbitrage elasticity of 1.47. Returning to Table 5.2, wheat and soybeans are two commodities in which an increase in exports (relative to production) beyond their mean levels would result in a greater percentage-wise reduction in the

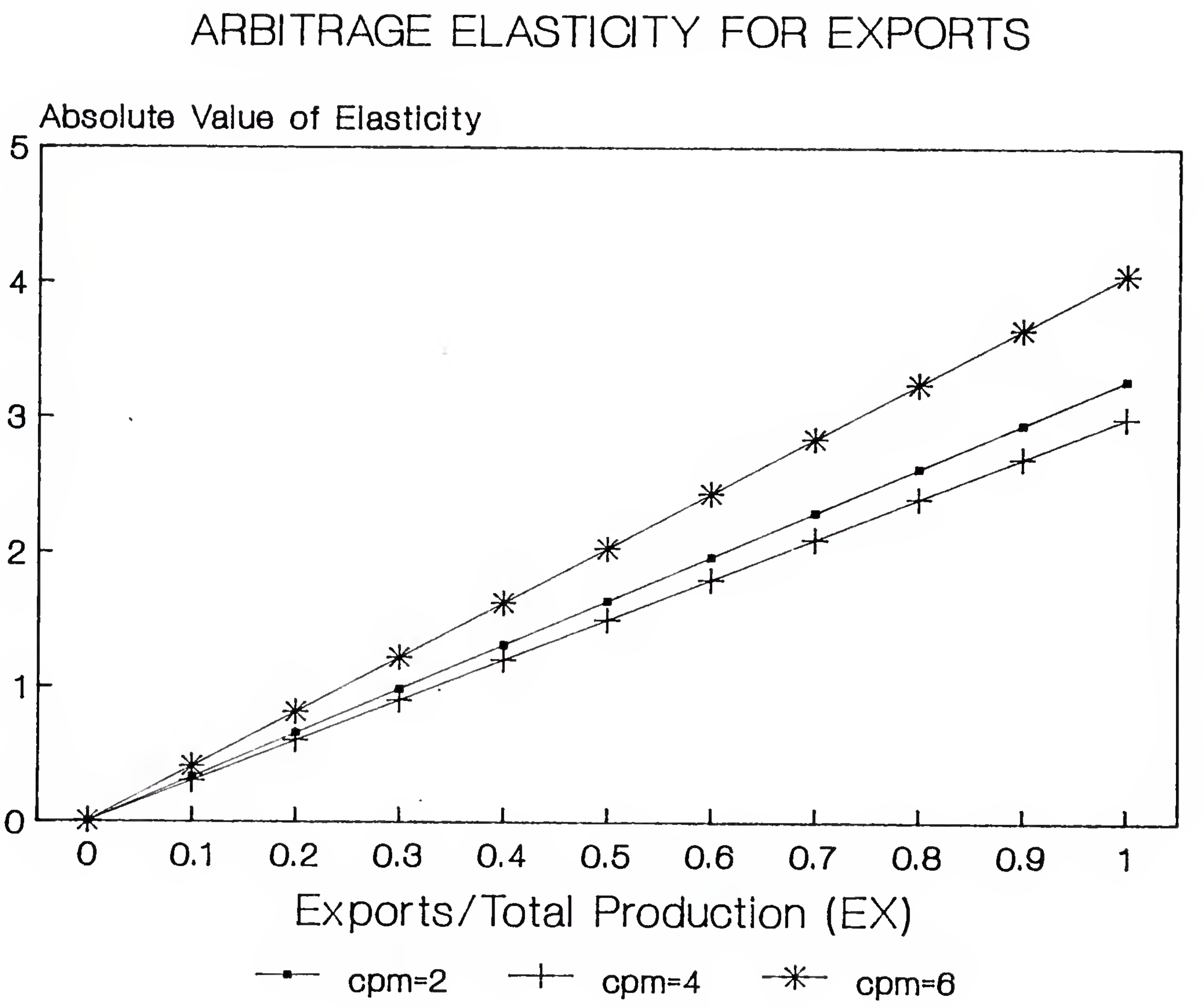

Figure 6.13. Simulated Effects of Exports on the Elasticity of Arbitrage.

variability in the basis residual. The mean values of EX for the other commodities occur in the inelastic region of the elasticity functions. For instance, one would not expect to see significant improvement in basis performance for oats as a result of an increase in exports.

Market Liquidity Elasticity

Again in absolute value, Figure 6.14 shows the arbitrage elasticity of market liquidity over the range of liquidity levels. The mean liquidity value corresponds to an arbitrage elasticity of 1.0 in the two month model, .75 in the four month model and .39 in the six month model. At one standard deviation above the mean, the four month model is in the elastic region.

The function for the six month model appears to be substantially less elastic than the two and four month functions. It was ascerted previously that the insignificance of the hedging ratio (HR) in the six month model implied that most hedges were made for periods of time less than six months. If this is true, then it is consistent that an increase in market liquidity (ML) would not be as beneficial to enhancing the integration between the cash and futures market in the six month model (where less hedging is present) as it would be in the two or four month models.

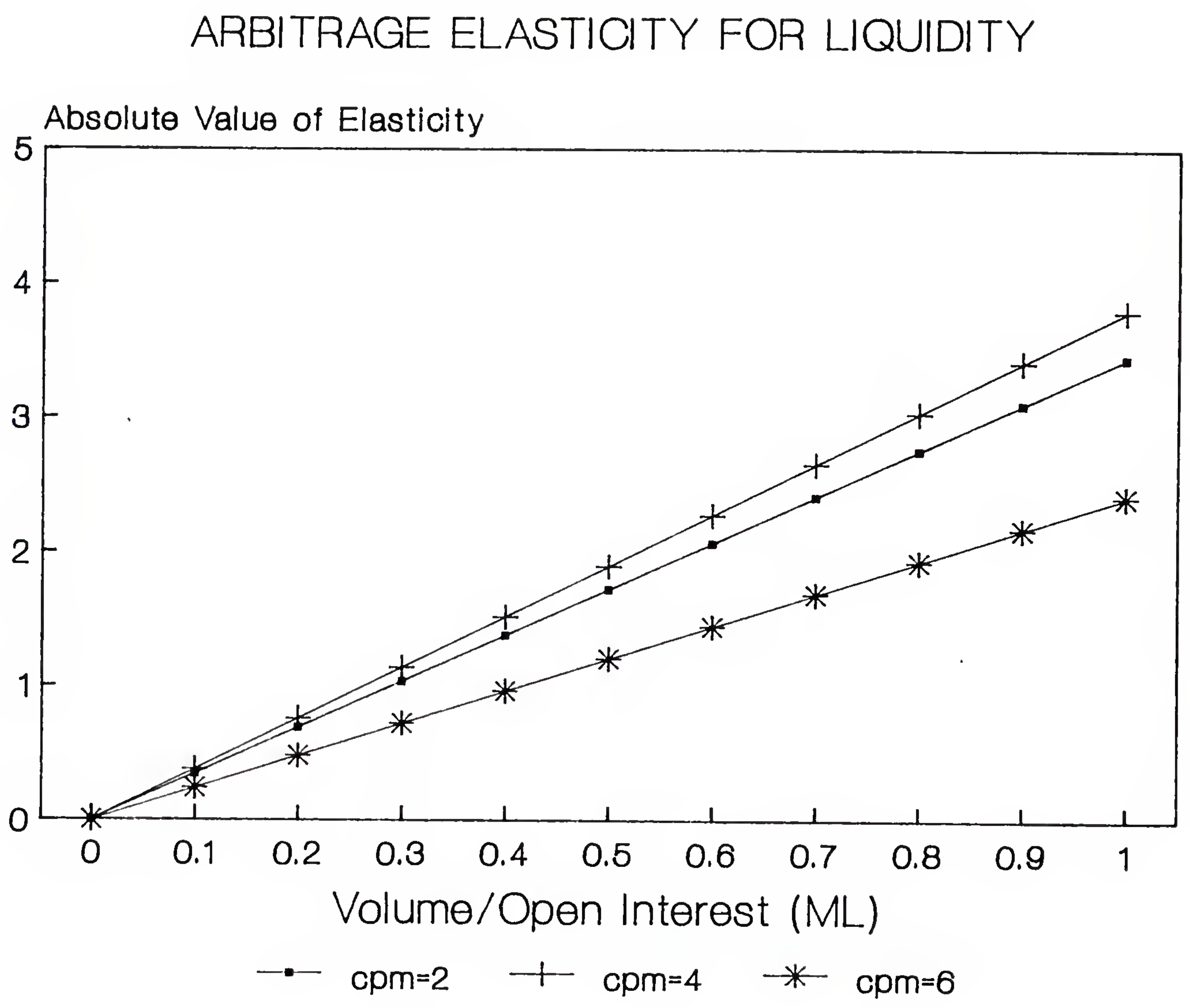

Figure 6.14. Simulated Effects of Liquidity on the Elasticity of Arbitrage.

Commodities in the analysis that are characterized by highly liquid markets include frozen pork bellies, soybeans and cattle, as seen in Table 5.2. The mean values of ML for these commodities correspond to the elastic region of the elasticity functions. However, as discussed in Chapter V, potentially benefical effects of increased market liquidity depend on the composition of traders (hedgers relative to speculators) that make up the increased volume.

Hedging Ratio Elasticity

The elasticity of arbitrage with respect to the hedging ratio (HR) is shown in Figure 6.15. For negative arbitrage elasticities, an increase in the hedging ratio decreases the variability in the basis residual or improves market performance. The six month elasticity function is negative almost throughout, yet the parameter estimates for HR and HR^2 are insignificant, as shown in Table 5.6.

The mean HR is .51 and just beyond this value the two and four month functions become negative. The mean HR is somewhat misleading, as the inclusion of the extremely low hedging ratio for pork bellies acts to bring the average down, as shown in Table 5.2. At one standard deviation above the mean, the elasticity functions are negative but still inelastic. It is not until hedged positions make up approximately 75 percent

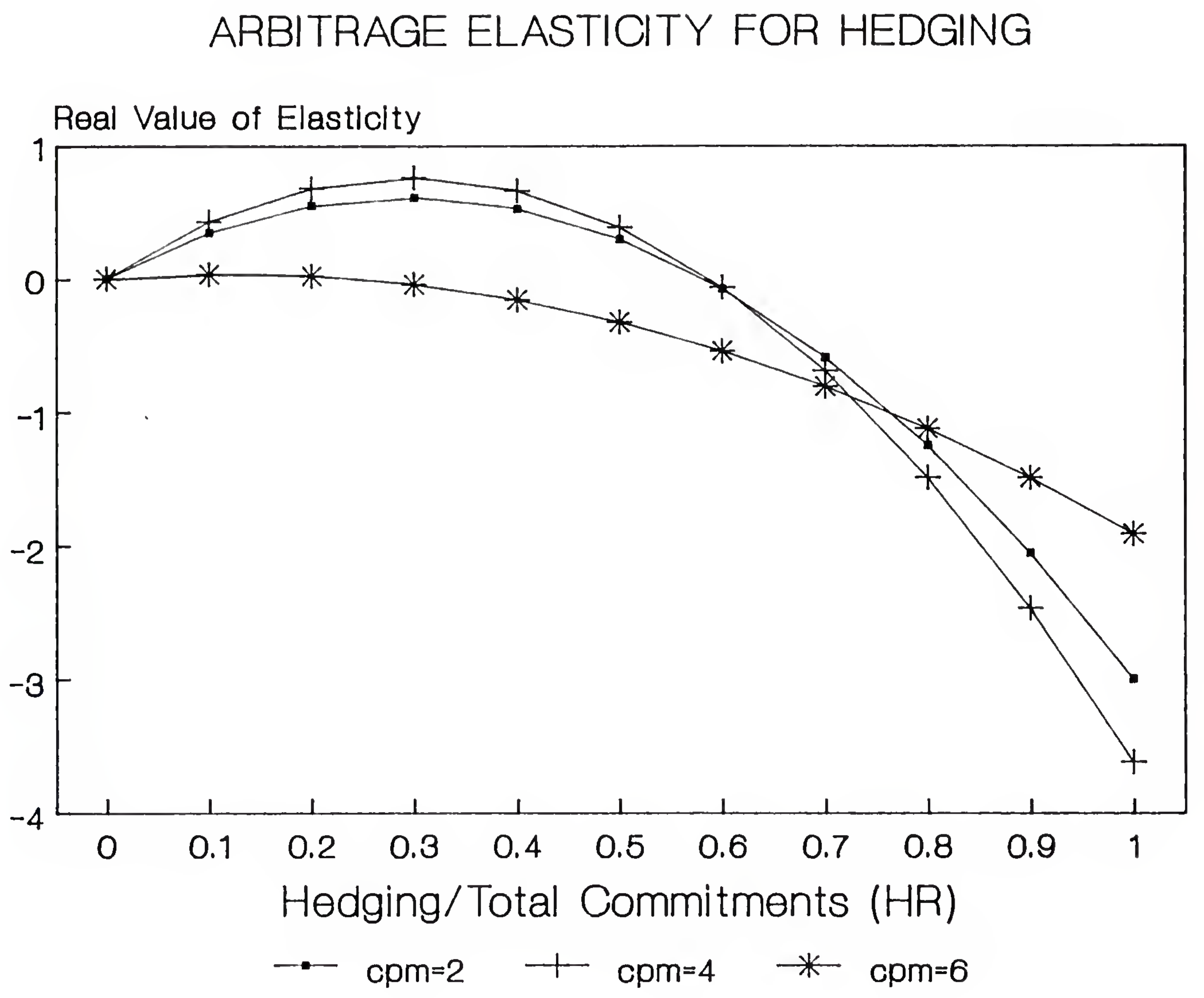

Figure 6.15. Simulated Effects of Hedging on the Elasticity of Arbitrage.

of the trading activity that an increase in the HR results in a greater percentage-wise reduction in the variability of the basis residual.

These results imply that basis performance could improve for commodities already characterized by relatively high hedging ratios, such as corn and FCOJ, as a result of increased commercial interest in the futures market. For a commodity such as frozen pork bellies with a HR of only .12, a dramatic increase in the industry's use of the market would be needed to improve basis performance.

Stock Index Elasticity

Figure 6.16 shows the elasticity fo arbitrage with respect to relative stock levels. The stock index is defined as the quarterly stock level divided by the average stock level in the corresponding year, and thus expresses stock levels relative to other times of the year. When the elasticity of arbitrage is less than zero, an increase in the stock index decreases variability in the basis residual.

As discussed in Chapter V, the initial segment of the stocks function, where an increase in the stock index causes increased variability, results because the uncertainty effect (related to the upcomming harvest) is confounded with the stock effect. For periods of the year when the uncertainty effect is not a factor

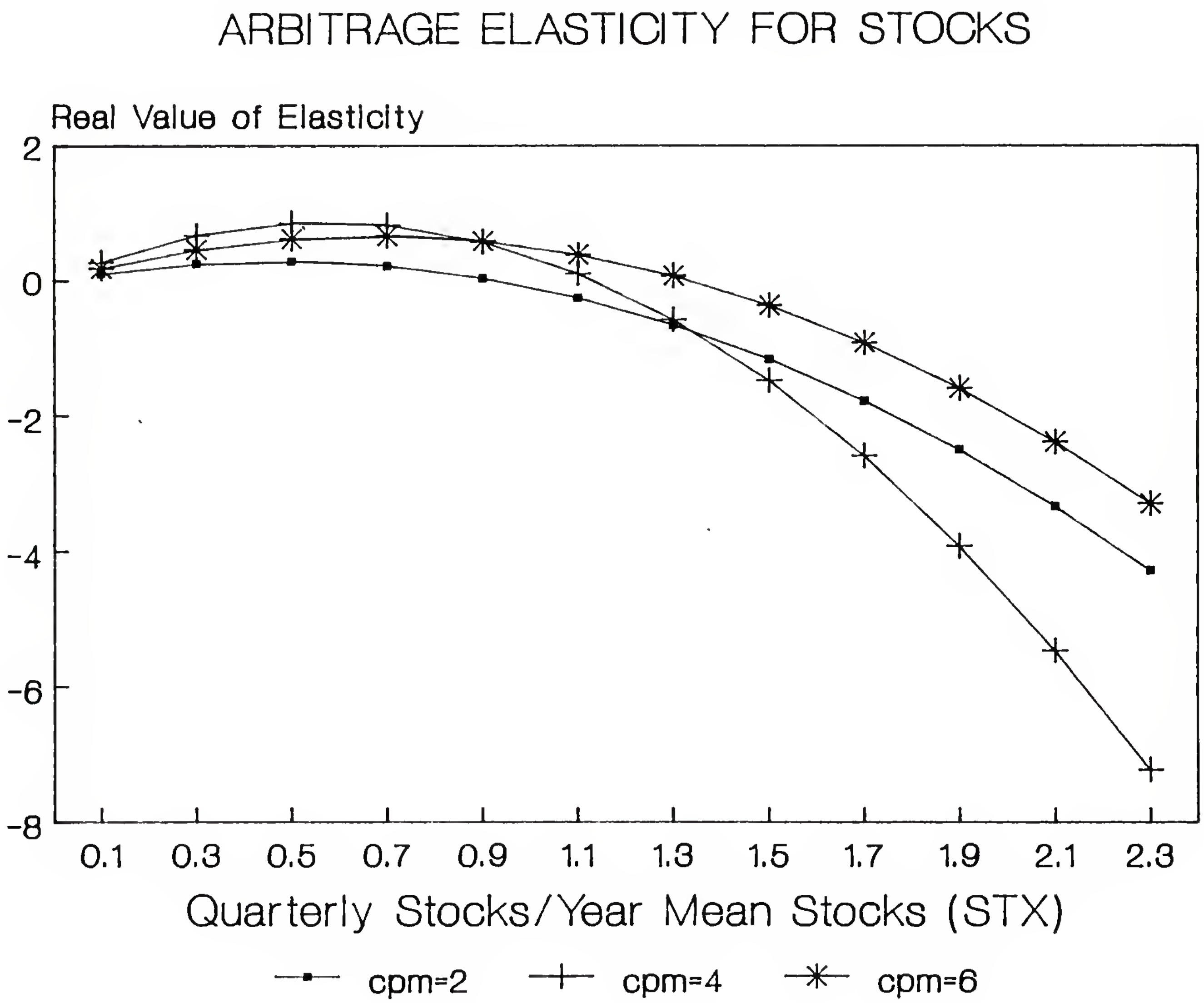

Figure 6.16. Simulated Effects of Stocks on the Elasticity of Arbitrage.

(corresponding to stock index levels of approximately 1.1 and greater) the arbitrage elasticities are negative.

In the two and four month models the functions become elastic at an index level of approximately 1.4. The slope of the four month elasticity function is particularly steep so that increases in the stock index at the higher levels have a dramatic effect on the relative reduction in the variability of the basis residual.

The results imply that during times of the year when stocks are abundant, the integration between the cash and futures market is strongest since the arbitrage potential is highest. This result is consistent with observed basis patterns.

A summary of results of the various elasticity measures is given in Table 6.1. This table shows arbitrage elasticities for the various exogeneous variables at their means. In the two month model, the arbitrage elasticity is negative and highest for market liquidity, followed by exports. In the four month model, the relative effects of EX and ML on reducing varibility of the basis residual are nearly equal. In the six month model, the effect of market liquidity on basis performance declines substantially as compared to the effect of exports. Because the hedging ratio and

Table 6.1. Arbitrage Elasticities With Respect to Alternative Exogeneous Variables at Their Mean Levels.

Variable (at mean)	The elasticity of the normalized standard deviation of the basis residual with respect to X_i (N_{axi})		
	2 month model	4 month model	6 month model
Exports (EX)	-0.82	-0.75	-1.01
Market Liquidity (ML)	-1.00	-0.76	-0.39
Hedging Ratio (HR)	0.26	0.35	-0.34
Stock Index (STX)	-0.09	0.37	0.50

stock index are quadratic functions, the arbitrage elasticities (at the mean) do not give much insight into the affect of these variables on basis performance.

Summary

The econometric results discussed in Chapter V were used in this chapter to investigate in further detail the relationship between the exogeneous variables and basis performance. Response functions simulating the effect that each independent variable had on the variability of the basis residual were depicted. Elasticity functions were shown and discussed.

Changes in the political and economic environment could be expected to alter market liquidity, exports or the hedging ratio. The results of this analysis indicate that such changes would affect basis performance. Alternatively, the stock index and the perishbility index, as defined, are physically related to the production characteristics of each commodity. Changes in these variables, that relate to the seasonality of production and perishability, can only result from technological change and are much less likely to occur than changes in the other variables. However, ascertaining that these variables affect basis performance is useful to understanding the forces that integrate the cash and futures markets.

CHAPTER VII
SUMMARY AND CONCLUSIONS

As an extension of the generally accepted theory of storage, basis determination models that explain the relationship between the cash and futures market have been developed for storable commodities. Futures markets exist for many nonstorable commodities, such as live cattle, feeder cattle, live hogs, potatoes and iced broilers. However, the relationship between these futures markets and the associated cash markets can not be examined within the theory of storage construct. In the present analysis a theoretical model of basis performance was developed that is generalized enough to accommodate storable and nonstorable commodities.

Arbitrage was identified as the competitive mechanism that integrates the cash and futures markets. Just as the competitive model can be used in price determination for any variety of markets that satisfy the competitive assumptions, an arbitrage model can be used to analyze the basis for a variety of commodities, whether storable or nonstorable. Basis performance, which reflects the integration between the cash and futures market, is determined by the potential for arbitrage between the two markets. The arbitrage potential is influenced by commodity and market characteristics and differences in these characteristics explain the different levels of basis performance among the commodities. Basis performance is important in determining hedging effectiveness as well as gauging market performance.

The basis was defined so that it represented a value enhancing transformation, either by time or form. The spatial dimension was not analyzed. In a time transformation, the physical characteristics of the input in the cash market are the same as the physical characteristics of the output in the futures market. In this type of transformation, the basis reflects a time value generated by holding stocks for deferred consumption.

In a form transformation the physical quality of the input and output differ. The commodity corresponding to the futures market represents the preferred or more useful form of the commodity. For instance, a form transformation is reflected by the basis defined as the live cattle futures price minus the feeder cattle cash price. A basis can also reflect both time and form transformations, as in the case of storing and crushing soybeans into soybean oil and meal.

The pertinent classification in this analysis is by time or form rather than the traditional storable-nonstorable approach. The reason to classify commodities by the value enhancing transformation is that under competitive assumptions, the transformation margin, or basis, should be consistent with the marginal cost of transforming. In the theoretical model, this approach is meaningful because it gives an indication of what the basis should ideally be. If we consider a basis level equal to cost to be consistent with the efficient allocation of resources, then one measure of basis performance is deviation of actual basis values from the cost level.

An analytical framework was used to examine the adjustment process between the cash and futures markets. Hedgers were identified as the potential arbitrators between the markets because they can potentially make or accept delivery of the commodity. Hedgers' buying and selling actions affect the relationship between prices in the cash and futures markets.

When the basis exceeds the cost of transformation, there is an incentive for hedgers to buy cash inputs and simultaneously sell futures contracts. The combined effect of these actions tends to narrow the basis with the direction of adjustment towards a basis that is consistent with cost. When the basis is less than cost there is no incentive to sell futures contracts and for those producers reluctant to initiate the transformation process unhedged, there is no incentive to buy cash inputs. These actions tend to widen the basis with the direction of adjustment towards the basis level that equals cost.

How strong the adjustment forces outlined above are at the aggregate level depends on what assumptions are made about producer behavior and industry characteristics. The theoretical model developed in this analysis is used to examine basis performance by applying the analytical framework to alternative assumption sets. The deviation of the basis from cost is a function of the arbitrage potential between the cash and futures markets. In turn, the arbitrage potential is influenced by factors such as the degree of marketing and supply flexibility as well as producers' willingness to use the futures market.

The first version of the model results in a basis level equal to cost because by assumption there are no impediments to the potential to arbitrate and producers do not initiate transformations unhedged. In the other versions where these heroic assumptions are not maintained, factors that affect the arbitrage potential are identified. Commodity characteristics, such as the degree of perishability, the seasonality of production, the level of fixed cost in the transformation process and any time requirement necessary for a form transformation, can affect the arbitrage potential because these factors affect a producer's marketing or supply flexibility in making delivery on a futures contract. Accordingly, basis performance is positively related to supply responsiveness.

Other factors that effect the arbitrage potential relate to producers decision to hedge. At one extreme, if producers or other agents are not willing to use the futures market there is nothing to structurally integrate the cash and futures markets. In actuality, only a small percentage of the producers and handlers in most agricultural industries hedge. The decision to hedge is influenced by such things as attitudes towards using the futures market, price expectations and yield uncertainty. In addition, the technical performance of the futures market, as determined by such factors as market liquidity and trader composition, can influence the arbitrage potential.

The alternative assumption sets corresponding to the various versions of the theoretical model have different implications with respect to resource allocation and with whom the price risk falls. At a hypothetical extreme, if all producers and handlers use the futures market as a forward contracting mechanism and would not initiate unhedged transformations, then production decisions would be based on futures market prices. Thus, those trading in the futures market, or speculators, would formulate the allocative signals of what and when to produce, as well as carry the burden of price risk associated with predicting future supply and demand conditions. In this instance, the futures market must be evaluated in terms of its price forecasting ability; that is, does it represent an efficient method of predicting, obtaining and assimilating market information.

In the theoretical extreme stated above, the entire burden of price risk falls on the speculators in the futures market since producers and handlers are using the market to forward contract their activities. In a more realistic situation when the producers use the futures market to hedge their cash position but are not able to make or accept delivery in order to satisfy a futures contract, then the usefulness of the futures market in its risk shifting capacity depends on the variability of the basis, or basis risk. Accordingly, basis performance is the primary factor determining hedging effectiveness.

In the applied analysis an empirical measure of basis performance is developed. Since the variability of the basis or its distributional properties determine basis risk, a measure of variability is meaningful in gauging basis performance. As in the theoretical model, basis performance is defined in terms of the difference between the basis and the associated cost of transformation, or basis residual. Thus, variability in the basis residual offers a measure of basis performance that is meaningful in the present analysis.

The focus of the analysis is to investigate the relationship between basis performance and commodity and market characteristics. This perspective necessitates a cross-commodity approach that entails special consideration with respect to methodology in the regression analysis. In order to analyze variability across commodities, the dependent variable, or measure of basis performance, must be normalized so that it is independent of scale because, for instance, dollars per hundred weight and cents per bushel are not comparable. Therefore, the standard deviation of the basis residual is divided by the standard deviation of the corresponding cash price. Accordingly, with this method the units of measurement cancel out and the dependent variable reflects the variability of the basis relative to the variability of the cash price. This measure of variability is pertinent because is expresses basis risk relative to cash price risk, that is, the risk associated with a hedged position relative to a nonhedged position. In general, lower values of the normalized SD(BR) are associated with better market performance than higher values of SD(BR).

Nine agricultural commodities over approximately a fifteen year period are included in the empirical analysis. Six of the commodities represent time transformations, that is, basis values that reflect commodity storage: corn, wheat, oats, soybeans, frozen pork bellies, and frozen concentrated orange juice. Form transformations of feeding out cattle and crushing soybeans into soybean oil and meal are also included. Three models of basis performance are defined corresponding to two, four and six months from maturity. The interval of time until contract maturity is held constant in each model. That is, all basis observations pertaining to a particular model correspond to futures contracts maturing in the same length of time or as close as possible to the same length of time. By holding this time dimension constant, the integration between the cash and futures markets is revealed as a function of commodity characteristics rather than a function of time-until-maturity. These models are referred to as constant period from maturity (CPM) models.

For each commodity, time series data are used to calculate the basis residual as the weekly averaged futures price minus the weekly averaged cash price minus the corresponding cost of transformation. The basis observations are then grouped by year and quarter prior to calculating the standard deviation of the basis residual (SD(BR)). That is, the weekly data for each commodity within a particular year of a particular quarter are used to create $SD(BR)_{ijk}$ where i denotes commodity, j denotes year and k denotes quarter. This partitioning is advantageous because it increases the number of observations and helps control for the changes in the price and cost levels that occur over time.

Using the theoretical model as a guide, observable factors expected to influence arbitrage potential are identified and their effects on basis performance are hypothesized. These exogenous variables are based on yearly and in some instances quarterly data for the various commodities. Three degrees of perishability are identified and included as dummy variables.

As a result of using cross-commodity data, the error structure in the regression models was expected to be heteroscedastistic. Since the data were aggregated across time, that is, the standard deviation of the basis residual was calculated over the weekly observations pertaining to a particular year and quarter, the error structure was not expected to exhibit serial correlation. The independent variables, which vary across time, should reflect much of the cross sectional effects. Finally, the data were not balanced over all the commodities and the procedure for dealing with pooled cross-sectional time series is very complicated.

A weighted least square (WLS) approach was used to correct for heteroscedasticity. The variance structure was expected to differ by commodity and for computational convenience, the nature of the heteroscedasticity was assumed to be multiplicative. Mean corrections based on the various commodities were employed to weight the regression equations so that the transformed equations would be homoscedastistic. Specifically, the equations were estimated using ordinary least squares and the estimated residuals were then squared and regressed on commodity dummy variables in order to derive estimates of the mean values of the estimated residuals pertaining to each commodity. The parameter estimates from the dummy variable regressions where highly significant revealing that the variance from the first regression was heteroscedastistic and related to unobserved commodity characteristics. These parameter estimates or mean corrections were then used to weight the regression equation so that the variance would be homoscedastistic.

The overall fit of the WLS regressions for the two, four and six month constant period from maturity (CPM) models was good with adjusted R squares of .88, .89 and .87. In general, the signs of the estimated parameters were as hypothesized.

The variable exports (EX) was defined as exports divided by total yearly domestic production and is based on yearly data for the various commodities. The parameter estimates for EX were highly significant in the two, four and six month models and had negative signs, as was hypothesized. The large firms that carry on highly centralized export activities act to increase the arbitrage potential because they have the incentive to use the futures market and devote significant resources to keep abreast of current situations in the cash and futures markets. In contrast, markets for domestically consumed production are less centralized and include smaller firms with less incentive and resources to keep on top of the market. The result is that export activity acts to improve the integration between the cash and futures market and therefore, enhance basis performance. The import variable (IM) was highly correlated (negatively) with exports and was dropped from the model because of the associated multicollinearity problems.

The next two variables, market liquidity and hedging ratio, relate to the technical performance of the futures market. Market liquidity was defined as trading volume divided by open interest and reflects the ease of entry and exit in the futures market. As hypothesized, the parameter estimates for ML were negative in all three CPM models. In a thin market that lacks liquidity, traders incur higher costs in order to establish or close out futures positions because they are not able to trade at the price they desire. These excess costs act to decrease the integration between the cash and futures markets. In contrast, a liquid market facilitates trading so that potential arbitrators can respond quickly and with least cost to basis levels that are not consistent with the cost of transformation. Thus, increases in market liquidity act to decrease the variability in the basis residual.

The hedging ratio (HR) is based on quarterly trading data for each commodity and was defined as hedged positions divided by total reported positions. Since the sign on HR was positive, a squared term for HR was added to the two, four and six month models to allow the positive effect to occur at a decreasing rate. The hypothesized sign for HR was negative since a relative increase in hedged positions was expected to increase the arbitrage potential. The parameter estimates in all three models were positive for HR and negative for HR^2 and these variables were significant in the two and four month models.

Simulation of the results reveal that the HR function initially increases and then begins to decrease once the hedging ratio is above its mean level of approximately fifty percent. The results suggest that when a market is highly speculative, then slight increases in the number of hedged positions relative to total trading is not sufficient to improve the integration between the cash and futures markets. Once some threshold level or "critical mass" of hedged positions is reached, then the variability in the basis residual declines with increases in the hedge ratio. In addition, the insignificance of HR in the six month model indirectly suggests that hedges are typically placed for a shorter length of time than six months.

The variable STX represents quarterly stock levels relative to yearly mean stock levels. As in the case of the hedging ratio, the sign of STX was positive so a squared term was added to the model. The parameter estimates, which were significant in the two, four and six month models, were positive for STX and negative for STX^2. The anticipated sign for STX was negative since the variability of the basis residual was expected to decrease with an increase in available stocks.

The resolution of uncertainty about crop production brings about increased price volatility. This resolution of uncertainty and stock levels each follow seasonal patterns that are similar year after year. These two factors are contemporaneously correlated which causes the STX variable to confound the stock effect and the resolution of uncertainty effect. An increasing portion of the STX function results because the positive effect of uncertainty on price volatility dominates the negative effect that stock levels have on the variability of the basis residual. For stock levels not corresponding to the late summer months when the uncertainty effect is strong, the STX function is negatively sloped, revealing that increased stock levels benefit market performance by improving the arbitrage potential.

Three degrees of perishability were identified and treated as dummy variables. Storables include the grains and frozen concentrated orange juice, semistorable was defined as frozen pork bellies (which may be stored up to six months) and nonstorable was defined for cattle (corresponding to fresh beef). The coefficient for the storable classification was highly significant in all three models, that is, the variance in the dependent variable was significantly different for the storable (grains) compared to the perishable classification (cattle), which was the base. The semistorable coefficient was significant only in the four month model.

The mean level of variability in the basis residual was substantially greater for the nonstorable as compared to the storable classification, in the two, four and six month models. This result was expected because holders of storable products have greater flexibility in timing their marketing than producers of nonstorables. Since factors that affect marketing flexibility influence the arbitrage potential, storability was expected to improve market performance. In addition, the difference in the variability of the basis residual between storable and nonstorable was much greater in the two month model than it was in the six month model. This result was anticipated since there is no potential to complete the feeder cattle-live cattle transformation, that is, arbitrate, in the two month model as there is in the six month model. This inability of arbitrate in the two month time interval results in poor integration between the feeder cattle and fed cattle markets or high variability in the basis residual.

The variables discussed above were included in the empirical investigation because they were expected to influence the potential to arbitrate between the cash and futures markets. Commodity characteristic, including physical and marketing characteristics, influence variability in the basis residual that in turn influences the usefulness of the futures market as a risk shifting device. The arbitrage model offers a general approach to examining market performance under alternative conditions.

Changes in the economic environment which alter some of these commodity characteristics can be expected to affect market performance. For instance, government policy or exchange rates can affect exports which would be expected to change market performance. Alternatively, an increase in speculative interest in a futures contract may increase the volume of trading and market liquidity and therefore, be expected to enhance market performance. It may be possible to redefine a futures contract to be more useful to hedgers and thus improve the integration between the cash and futures markets. The results of the present analysis are useful in predicting how such changes might affect market performance.

Even commodity characteristics that appear to be intrinsic are subject to change as a result of changing technology. For instance, consider the effect that refrigeration and freezing has had on marketing flexibility for perishable commodities. Factors that improve a producer's marketing flexibility and control help reduce price risk whether a futures contract exists or not. If a futures contract does exist, then increased marketing flexibility can be expected to improve basis performance. One could expect to see new futures contracts as technological advances make this method of reducing price risk feasible. Alternatively, existing futures contracts may be discontinued as economic conditions change.

The present study represents a general approach to identifying broadly defined factors that influence basis performance. Further research is needed to ascertain how these factors effect producers' returns to hedging. Performance was gauged by the deviation of the basis from the transformation cost. This deviation may be asymmetric, that is, the likelihood of a narrow basis may be greater than a wide basis. This aspect of the distributional properties of the basis affects the potential returns to hedging depending on whether a hedge is long or short. In addition, the composition of long and short hedges pertaining to a futures contract could be expected to influence basis variability, as well as distribution.

Further research is also needed to analyze in detail the effect that the time until maturity has on basis variability and the returns to hedging. Such analysis would be useful to advising producers as to the best time to place a hedge. It would be beneficial to know what influences producers' decisions concerning whether or not to use the futures market. It would also be useful to know how the performance of the futures market is related to the percent of an industry that uses the market in hedging.

APPENDIX

Futures Market Exchanges and Corresponding Cash Market Used to Create Basis Values.

Futures contract	Exchange	Cash market	Description for cash mkt
Corn	CBT	Corn	#2 yellow central Illinois
Wheat	CBT	Wheat	#2 hard Kansas City
Oats	CBT	Oats	#2 milling Minneapolis
Soybeans	CBT	Soybeans	#1 yellow central Illinois
FCOJ	NYCE	FCOJ	frozen concentrate New York
Frozen pork bellies	CME	Frozen pork bellies	12-14 lb. Mid-US
Soybean oil	CBT	Soybeans	#1 yellow central Illinois
Soybean meal	CBT	Soybeans	#1 yellow central Illinois
Live cattle (11 cwt)	CME	Feeder cattle	6 cwt steers Oklahoma City

CBT - Chicago Board of Trade
NYCE - New York Cotton Exchange
CME - Chicago Merchantile Exchange
FCOJ - Frozen concentrated orange juice

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BIOGRAPHICAL SKETCH

Sandra Johnson Monson was born October 14, 1958, the third child of Fred and Virginia's four children. She grew up in Atlanta, Georgia.

She entered the University of Georgia as an art major in 1976. In 1980, she received her Bachelor of Science degree in agricultural economics, graduating magna cum laude. She accepted a teaching assistantship at Iowa State University and earned a Master of Science degree in 1982 from the Department of Agricultural Economics specializing in finance.

While at Iowa State, she met her husband to be, Michael James Monson. In August of 1982 she (and Mike) entered the graduate program of the Department of Food and Resource Economics as a research assistant in order to pursue a doctoral degree. She married Mike on July 2, 1983, and on August 16, 1984, they were blessed with their first child, Jeffery James.

Sandra moved with her family to Columbia, Missouri, in the fall of 1986 and is expecting her second child.

I certify that I have read this study and that in my opinion is conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Ronald W. Ward
Ronald W. Ward, Chairman
Professor of Food and Resource Economics

I certify that I have read this study and that in my opinion is conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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Richard L. Kilmer
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I certify that I have read this study and that in my opinion is conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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